PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON
PLANT DISEASES AND PESTS

Published quarterly for the
Ministry of Agriculture, Fisheries and Food
Plant Pathology Laboratory
Harpenden, Herts

VOLUME 10, No. 4
December 1961

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POTATO BLIGHT FORECASTING IN CUMBERLAND, 1953-57

by H. E. CROXALL,* W. A. DAVEY, D. C. GWYNNE† *and* W. JOHNSON
National Agricultural Advisory Service, Northern Region

IN 1952 blight killed the haulm of maincrop potatoes by early August in the Brampton district of Cumberland. As late frosts and exposed fields in this district are not conducive to early planting or rapid bulking, there was a serious reduction in yield. Tuber infection was also high and was of especial concern to a number of farmers in the district who are seed producers. The occurrence of Beaumont periods at Silloth on the Solway coast had given good warning of early outbreaks in this locality in 1952. But it was desired to test the extent to which warnings from the coastal station would prove valid for the upper Eden Valley, where the topography is very variable, some of the potato fields being in sheltered places at an altitude of 400 ft and others on exposed slopes up to 800 ft, with possible wide differences in humidity and temperature.

In 1953 an investigation was started, not only to check the zone that warnings from Silloth could be expected to serve, but also to see whether the meteorological information from Silloth could usefully be supplemented by simple records made on farms, and thus to develop, if necessary, a local system of obtaining warnings of the need for protective spraying. In connection with this work a field survey was planned to obtain blight outbreak dates and to reveal the actual range of difference in blight incidence in different parts of the area.

With the guidance of Mr. L. P. Smith, of the Agricultural Branch of the Meteorological Office at Harrow, wet and dry bulb thermometers were set up in small standard screens, 4 ft above ground level, at a number of farms located as shown in the map (Fig. 1), and the farmers were asked to take readings of the instruments three times each day (at 0900, 1200 and 1500 hours G.M.T.) over the period from July 1 to August 30. As it was necessary for the instruments to be easily accessible, the screens were not put in potato fields but at convenient places near the farmhouses, but clear of farm buildings and trees. In 1953 the "farm stations" were concentrated in the Castle Carrock-Carlatton area, but in later seasons they were more widely dispersed, as shown by the map (Fig. 1) and by the station numbers appearing on the chart of results (Fig. 2).

For the purpose of the investigation a critical high-humidity period at a farm station was arbitrarily taken as one in which the relative humidity was 90 per cent or more on any three consecutive readings of the wet and dry bulb thermometer, with the dry bulb temperature at least 50°F. A period was regarded as near-critical when the relative humidity fell to not less than 85 per cent at not more than one of three consecutive readings. It was considered that if the humidity in the farm screen was over 90 (or 85) per cent at the beginning and end of the three hours between readings during the day it was most unlikely to have fallen below that level within a potato crop during the three hours; and also that if it was over 90 (or 85) per cent in the screen at

*Now at N.A.A.S., Wolverhampton
†Now at N.A.A.S., Bangor

1500 hours in afternoon and again at 0900 hours on the following morning it was unlikely to have fallen to less than this in a potato crop during the night. In effect, when the humidity in the screen was 90 per cent on three consecutive occasions it was probably over 90 per cent within the crops for at least 18 and often for 24 hours.

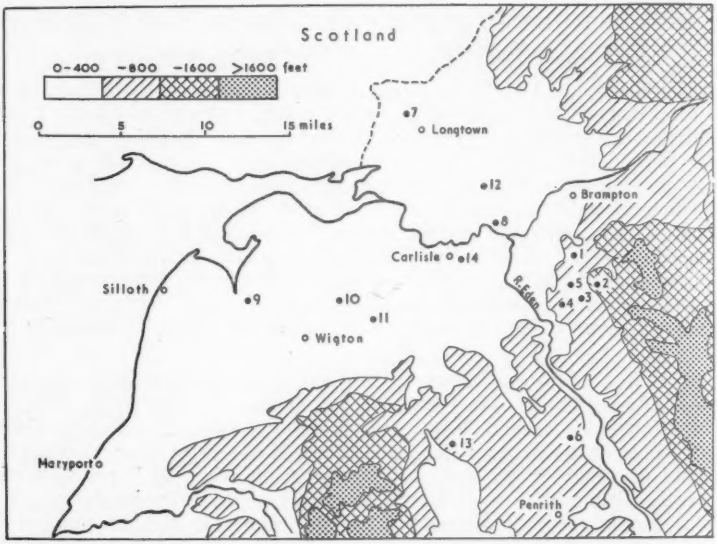

Fig. 1. Location of the farm stations. The altitudes of the stations (in feet) were:

1. 475	2. 700	3. 525	4. 400	5. 475
6. 600	7. 50	8. 150	9. 100	10. 50
11. 125	12. 175	13. 600	14. 100	

The records were started each year on July 1—as before this the crops were not touching in the drills. For the study of the correspondence between the humidity records and blight outbreaks a weekly survey of potato fields in the vicinities of the farm stations was made each year and the progress of blight was recorded using the BMS key. Fig. 2 shows the farm stations which participated in each of the several years, the high-humidity periods at these stations, with the Beaumont periods at Silloth for comparison, the date on which blight was first seen each year, and typical blight progress curves. The curves are for Redskin, the variety most commonly grown in the area, except where otherwise stated.

EXPERIENCE IN 1953

Three of the farm stations had high-humidity periods on July 9 and all had such periods on July 13, coinciding with a Beaumont period at Silloth on July 11-13. There was similar agreement between Silloth and the farm stations during August 6-8 and August 29-September 2. Several of the farm stations had high-humidity periods about July 27 and August 13-15, when there were no Beaumont periods at Silloth.

Blight was first seen on July 31 in one field of Home Guard and one of Majestic. During the following week it was seen in all 28 of the fields surveyed

—which included 18 of Redskin. The first two outbreaks corresponded with the Beaumont period and the high humidities at farm stations about July 13, but the general outbreak a week later was more in accord with the high-humidity periods at the farm stations about July 27. There was little difference in the progress curves for the disease in different situations, except that the early-planted crops tended to reach the 50 per cent stage more rapidly than those planted later.

A small-scale replicated spraying trial was carried out on Redskin at Black Dub Farm, Carlatton (Farm Station 5). The progress curves in Fig. 2 for 1953 are for this station, and they show the effect of a single application of a copper spray on August 7, when the first spots of blight were seen on the field—but outside the trial area. The application gave nearly three weeks prolongation of growth (in September) with an increase of yield of from 8·4 to 9·4 tons per acre.

EXPERIENCE IN 1954

In 1954 a Beaumont period at Silloth on July 1-3 was not supported by high humidity readings at any of the farm stations, but a second period on July 15-19 was accompanied by "near-critical" readings at four of the stations. High humidities at all stations occurred at the start of the Beaumont period at Silloth on July 23-25, but the Beaumont period on July 26-30 was accompanied only by near-critical readings at three of the stations. The correspondences with later periods may be seen from the chart (Fig. 2).

The field survey for blight in 1954 included 25 fields of which 17 were Redskin. Blight was first seen in one crop of King Edward on August 6, and in the following week it was found in all 25 fields. This starting date suggests that the warnings given by the Beaumont period at Silloth on July 23-25 and by the corresponding high-humidity periods at farm stations at that time were valid, but the earlier Beaumont periods at Silloth were not. In spite of the long spells of high humidity in August, blight progressed slowly in all the crops, probably owing to low temperatures over most of the month.

At Saughtree Gate Farm (Farm Station 3) a trial was laid down to show the best date for spraying following the warning periods on July 23-25. Single applications of a copper spray were made on replicated plots of Redskin on July 28, August 6 or August 13. Heavy rain immediately following the application on August 6 rendered this treatment ineffective. The sprayings on July 28 and August 13 each gave about 7 days prolongation of growth with an increase of yield from 9·4 to 10 tons per acre.

EXPERIENCE IN 1955

In 1955 two more farm stations (Nos. 7 and 8) were added to obtain information for the low-lying land between Brampton and the Scottish border. There was a broken Beaumont period at Silloth on July 5-7, without high humidities at the farm stations. On August 9 there were high humidities at all the farm stations without a Beaumont period at Silloth. Broken Beaumont periods occurred at Silloth between August 18-22, but only one of the farm stations had a high-humidity period at this time.

The weekly field survey included 26 fields of which 20 were of Redskin. Blight was first seen in Dr. McIntosh in a variety trial planted within a Redskin crop at Oak Bank Farm, Longtown (Farm Station 7). This outbreak could be related to the high-humidity periods at the farm stations on August 9, or to the broken Beaumont periods at Silloth on August 18-22. Blight spread to the Redskin surrounding the variety trial by the first few days in September, but

it was not seen elsewhere in the survey area until September 16, when it was found in all the fields. This suggests that the early attack on Dr. McIntosh was due to primary infection within the plot, and that the general outbreak in

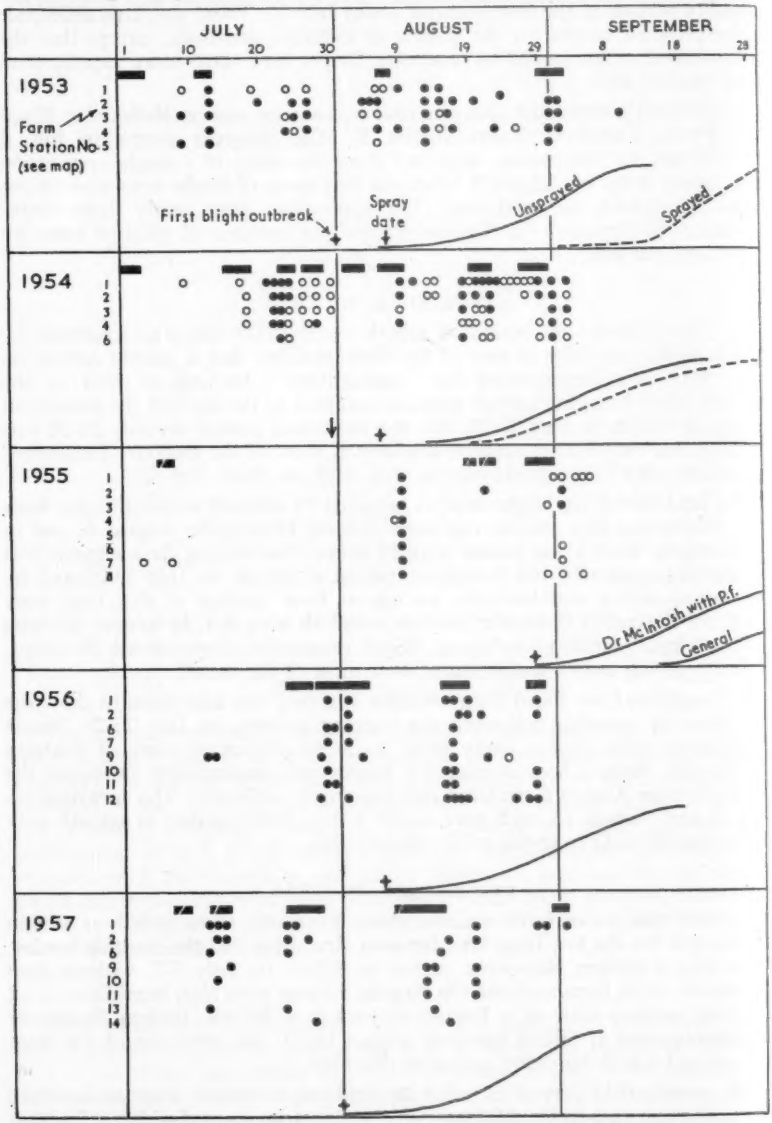

Fig. 2. High-humidity periods at farm stations in relation to Beaumont periods at Silloth, first blight outbreaks and blight progress curves, in Cumberland, 1953-57.

the other fields corresponded with the first full Beaumont period at Silloth on August 27-31, about which time there were also full or partial high-humidity periods at most of the field stations. No spraying trials were carried out in this dry season.

EXPERIENCE IN 1956 AND 1957

In 1956 farm stations Nos. 1, 2, 6 and 7 were retained, and new stations (Nos. 9, 10, 11 and 12) were set up to cover the coastal plain between Silloth and Carlisle (Fig. 1). There were three almost continuous Beaumont periods at Silloth from July 23 to August 4 in this year and all the farm stations had high-humidity periods at this time.

In this year, with a much wider area to be covered, the field survey for blight was made on the crops nearest to each of the farm stations. Blight was first seen at West Brownrigg, Plumpton (Farm Station 6) on August 6. Further outbreaks were found in some fields near all stations during the week August 11-17, in good correspondence with the prolonged Beaumont periods and also the high-humidity periods at farm stations, between July 23 and August 4. There were no spraying trials in this year; the course of blight on the unsprayed crops was as shown by the progress curve in Fig. 2 in all parts of the area.

In 1957 the area covered was similar to that in 1956, with farm stations Nos. 13 and 14 substituted for No. 12. None of the farm stations recorded high-humidity periods corresponding with the broken Beaumont period at Silloth over July 7-10, but there was fairly good agreement between Silloth and the farm stations on later occasions (Fig. 2). Blight was first seen in fields near stations 1, 2 and 6 on July 31, and in crops near the remaining stations by August 7, in good correspondence with the full Beaumont periods at Silloth and the high-humidity periods at the farm stations.

DISCUSSION

During the six seasons there was in general good agreement between the Beaumont periods at Silloth and the high-humidity periods at the farm stations. Except on a very few occasions there was also close agreement between the farm stations themselves; indicating that local variations were not as great as might have been expected, and that despite the differing altitudes of the farm stations the course of blight was much the same over the whole area, that is to say within a radius of about 25 miles of Silloth (see Fig. 1).

There was no indication that individual high-humidity records at single farms could safely be used for forecasting blight outbreaks even in their immediate vicinity. This was not surprising, as many factors, including variety, date of planting, state of growth and presence or absence of infection sources within a crop, must all play a part in determining date of outbreak. The chart (Fig. 2) does show, however, that records from a *group* of farm stations can serve for practical blight forecasting.

It is not suggested that a warning system based on the records of groups of farm stations reading wet and dry bulb thermometers only three times each day could take the place of regional forecasting based on flushes of Beaumont periods occurring over a network of meteorological stations as described for England and Wales by Large (1953 and 1956). Group records from farm stations, however, may provide a valuable means of supplementing the national scheme in particular localities.

After this work in Cumberland had started, Smith (1956) showed that periods of 90 per cent relative humidity persisting for at least 11 hours during each of

two consecutive days, with minimum temperature at least 50°F, might be used successfully in potato blight forecasting. Although much less precise, readings of 90 per cent relative humidity, with the same minimum temperature, made on three successive occasions at 0900, 1200 and 1500 hours G.M.T. will often indicate similar blight conditions, because high-humidity conditions may be expected to prevail within potato crops during the nights preceding or following the critical day-time observations.

SUMMARY

A local potato blight forecasting scheme based on the occurrence of relative humidities of at least 90 per cent, with minimum temperature 50°F, in three successive readings of wet and dry bulb thermometers in screens at 0900, 1200 and 1500 hours G.M.T. at a group of farm stations was investigated over an area of about 200 square miles in Cumberland, during the years 1953-57. It was found that the indications *from the group of stations* using this simple rule were generally in good agreement with the Beaumont periods occurring at Silloth (where readings were made hourly throughout the day and night) and that on some occasions they provided valuable supplementary evidence for local forecasting.

We are grateful to Mr. L. P. Smith of the Agricultural Unit of the Meteorological Office for his help in this work; and we wish to express our special thanks to the following farmers and their families who read the thermometers three times daily over long periods at the farm stations shown on the map (Fig. 1) namely:

1. Mr. A. Thwaites, Castle Carrock
2. Mrs. Forster, Brackenthwaite
3. Mr. G. V. Maughan, Carlatton
4. Miss M. Wilkinson, Carlatton
5. Mr. W. S. Maughan, Carlatton
6. Mr. K. Lowthian, Plumpton
7. Mr. E. Faulder, Longtown
8. Mr. J. A. Graham, Crosby
9. Mr. J. Reed, Kirkbride
10. Mr. Reay, Wiggonby
11. Mr. H. Peel, Thursby
12. Mr. W. H. Barker, Scaleby
13. Mr. T. Mitchell, Skelton
14. Mr. A. C. Ketchin, Carlisle

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SIZE AND PRICE INCREASE

In the ten years of its publication *Plant Pathology* has proved itself indispensable to research and advisory workers in this country, and is now widely read throughout the world. To give greater coverage of important work of particular interest to our readers, the number of pages in each issue will be increased to 48 (plus 4 pages of illustration) as from Vol. 11 (No. 1), March, 1962.

We regret that in consequence, the price of single copies of *Plant Pathology will be 7s. 6d. (7s. 10d.* by post) as from March, 1962, and the subscription rate for four issues will be *31s. 4d.* including postage.

Current subscriptions will be subject to the new rates on renewal.

OBSERVATIONS ON THE CHEMICAL CONTROL OF PEA MIDGE ON GREEN PEAS IN YORKSHIRE

by W. J. BEVAN

National Agricultural Advisory Service, Leeds

THE freezing and canning industries and green pea market require supplies over a prolonged period necessitating the sowing of peas from late February or early March up to the second week or so of May. Bevan and Murdoch (1958) showed that peas sown before mid April and in drier seasons up to the end of April do not usually suffer serious losses in yield as a result of attack by the pea midge, *Contarinia pisi* Winn. The later-sown crops tend to be heavily infested at or before the beginning of flowering and consequently suffer heavy losses in yield. These later sowings therefore need protection in years when attacks by pea midge are severe.

Emergence, mating, dispersal and oviposition occur in a short space of time in many midge species (Barnes, 1946). Observations confirm that this is also true of the pea midge (Franssen, 1954; Bevan and Murdoch, 1958). Barnes (1946) quotes Kutter's work stating that, "the adults may live as long as 6 days" but he suggests that this is rather a long period for adult midges. Franssen (1954) stated that Nijveldt succeeded in keeping adults alive for 5 days on plants. Barnes (1946) and Franssen (1954) agree that the actual duration of life is probably greatly influenced by the relative humidity and temperature. Observations in Yorkshire suggest that the usual length of time a female pea midge lives is probably in the region of 2 or 3 days under field conditions. Examination of plants in untreated crops has shown that they were free of midges and eggs at 1900 hours G.M.T. on the day previous to emergence, but were infested with gravid females, and large numbers of eggs had been deposited 14 hours later. Dead midges were found in numbers within 48 hours.

Consideration of the phenology of the midge suggested that a reliable method of forecasting might be helpful in the chemical control of this pest. Work began early in June 1957 on a study of the rate of pupation of midge larvae in soils of fields which had carried heavily infested pea crops in the previous season, with a view to forecasting dates of emergence of adults. The results suggested that midges would first emerge during the last two or three days of June and continue into early July (Bevan and Uncles, 1958). In previous years field observations showed that adults were in the pea crop in late June but tended to be most abundant towards mid-July. Work in recent years in Yorkshire further suggested that the earliness and intensity of emergence are dependent on the soil temperature prevailing during the last two weeks or so of June. Franssen (1954) indicates that the earliest emergence of midges occurred in traps located in sunny positions in the fields containing the over-wintering larvae.

While it is now possible to forecast the dates of emergence and to some degree the initial intensity of adult activity, the successful migration to the pea crop depends on favourable weather conditions prevailing over the period of emergence.

EXPERIMENTS ON CONTROL

DDT has proved reasonably successful against the black currant midge, *Dasyneura tetensi (Rübs.)* on black currants in this country, and in Holland it

has been used against pea midge with varying success by Franssen (1954). He found that oil emulsion sprays were not as successful in trial plots under conditions of heavy attack as they were with lighter attacks, but on a field scale similar sprays were reasonably successful when used at the beginning of attacks. Consequently, trials were carried out at two sites in South Yorkshire in 1957 to compare the value of DDT with dieldrin, Dipterex and diazinon in protecting crops in the early stages of flowering against attack by pea midge.

At each site, there were two series of treatments. The first consisting of an application of insecticide on July 27 and again 10 days later, and the second of a single spray applied 5 days after the first midges were seen. Plots were 0·01 acres in area and all treatments were repeated twice. Sprays of various concentrations of insecticide were tested and were applied at the rate of 100 gallons per acre. Miscible oil formulations were used except in the case of Dipterex which was a wettable powder. A small quantity of wetter was added to all sprays except diazinon where the formulation used already contained adequate wetter. The crop near Pontefract was sown on April 27 and when sprayed was showing one flower. The crop near Doncaster was sown on May 3 and was about to flower when sprayed. Adult midges were found in the crops on June 28 and activity was high for a few days. Midges were found readily under suitable weather conditions up to the second week of July. Samples of plants examined on July 2 showed that egg laying was heavy in the plots. At both sites 50 plants were chosen at random within each plot on July 16 and the numbers of marketable pods per plant were recorded (Table 1).

TABLE 1

Results of Trials in South Yorkshire, 1957

Treatment	Chemical	Active ingredient per application *oz per acre*	Mean number of pods per vine
One spray the day before and one 10 days after the start of the attack.	Dieldrin	6	3·95
	Dieldrin	12	3·35
	Dieldrin	18	3·85
	DDT	10	3·75
	DDT	20	3·35
	DDT	30	4·15
	Dipterex	6	2·42
	Dipterex	12	3·12
	Untreated	0	2·96
	Significant difference (p = 0·05)		0·65
One spray five days after the beginning of the attack.	Dieldrin	15	3·52
	DDT	20	3·32
	DDT+Dipterex	20+6	3·00
	DDT+Diazinon	20+6	3·20
	Diazinon	6	3·27
	Diazinon	12	3·67
	Dipterex	6	3·30
	Dipterex	12	2·52
	Untreated	0	2·80
	Significant difference (p = 0·05)		0·62

The attack was heavy but all the insecticide treatments were associated with increases in yield except Dipterex, which gave inconsistent results. Two

applications of DDT increased yields by approximately 22 per cent and dieldrin by 19 per cent. The single applications resulted in significant increases in yield in the case of diazinon at 12 oz per acre and dieldrin at 15 oz per acre.

The results suggest that two sprays of DDT and dieldrin were more successful than one. One of the main factors contributing to this result was probably the timing of the application of the treatment relative to the midge attack. In the two-spray plots the first spray was applied less than 24 hours before the first midges were seen in the crops. In the single-spray plots large numbers of eggs had been deposited prior to spraying but attack continued sporadically for about 3 days after. The second spray probably had relatively little influence on the results as adult midge activity was very low on the day of the application and on the days following.

On commercial fields in South Yorkshire, later sown crops sprayed once with DDT oil emulsions at high volume immediately before or at the beginning of midge attack showed increases in yield. These increases were not spectacular, but were stated to have produced a cash profit of £2 to £4 per acre after deducting the costs of the treatment.

PROBLEMS ASSOCIATED WITH PEA MIDGE CONTROL

Examinations of plants in trial plots, where insecticide treatment had been applied on the day previous to attack, showed that oviposition was often heavy in treated and untreated plants within 24 or 48 hours of the application of insecticides. Large numbers of adults were seen to be killed by the treatments, but this did not appear to result in obvious marked reduction in egg deposition. Thus it would appear that, when large numbers of midges were coming in to a treated pea crop, either these adults were not becoming contaminated at all or to a sufficient degree; if they were contaminated sufficiently the insecticide did not cause paralysis or death quickly enough to prevent oviposition; or the initial action of the slower killing insecticides caused intense muscular activity which may lead to the involuntary deposition of eggs from the gravid female midges.

While adults may be seen making short flights within the crop in calm weather, far larger numbers are found within the terminal shoots. In windy or wet conditions adults tend to remain within the terminal shoot. A large proportion of the midges which have migrated into a crop immediately before it was sprayed, may therefore oviposit before being contaminated by the insecticide.

The growth habit of the pea plant is such that the leaflets ensheathing the terminal shoot unfold exposing the first two flower buds; as these develop further and open successively stem extension takes place. This process is repeated progressively; as more buds are exposed the first flowers will have set, and their pods will have begun to extend. Thus with one insecticidal treatment it is possible to contaminate the exterior of the vulnerable terminal shoot for a relatively short period only. Repeating the treatment will only give a further short period of contamination to the terminal shoot. Midges may therefore enter and oviposit in the terminal shoot of a sprayed plant, within a few days of the application of the insecticide, without becoming contaminated.

RAPIDITY OF KILL OF ADULTS

In an endeavour to achieve greater success in controlling this pest, attempts were made to kill the adults more quickly. Trials were carried out in 1958 and 1959 designed to obtain data on the rapidity of kill of adults by various insecticides. Plots were 0·01 acres in area and treatments were applied on the

first day of the midge attack at a time when numbers of midges were present in the crop. Counts of live and dead midges were made on 50 plants per plot at 0·25, 1·5 and 20 hours after spraying. The results are summarized in Table 2.

TABLE 2

Rapidity of Kill of C. pisi *Adults in the Field*

Insecticide	Active ingredient *oz per acre**	Percentage of midges dead after:		
		0·25 *hours*	1·5 *hours*	20 *hours*
1958				
Phosdrin	2	81	100	100
Phosdrin	4	100	100	100
Diazinon	8	71	100	100
Diazinon	20	74	100	100
Malathion	20	63	100	100
Dimethoate	8	15	29	72
Demeton-methyl	10	26	40	67
DDT + Phosdrin	40+2	82	100	100
DDT	40	38	93	100
Dieldrin	15	43	92	100
No treatment	0	0	6	7
1959				
Phosdrin	2	97	100	100
Malathion	18	63	100	100
DDT	25	46	100	100
Thiodan	25	60	100	100
W.L. 1650	25	82	100	100
No treatment	0	0	0	75

* in 100 gal (1958); or 50 gal (1959)

Phosdrin showed the most rapid action, followed by diazinon, W.L. 1650 and malathion. Under the hot conditions of 1959 Phosdrin killed adults within the terminal shoots within a few seconds of the spray hitting the plants. All the insecticides gave a high percentage kill within 1.5 hours except demeton-methyl and dimethoate. There appeared to be very little difference in the action of the insecticides at high or medium volume. In other observations Phosdrin at 2 oz; diazinon at 4 oz; and malathion at 18 oz, applied in 25 gal of water per acre, respectively, gave kills within 1·5 hours similar to those obtained at the higher volumes. The figures for kills at 0·25 hours with low volume sprays were not so consistent as with higher volumes. W.L. 1650 appeared to be the most effective of the chlorinated hydrocarbons at medium volume.

In the 1958 trial, 20 hours after treatment, 92 per cent of the midges recorded in the untreated and approximately 30 per cent of those in the demeton-methyl and dimethoate plots were alive; no live adults were found in any of the other plots. In the 1959 trial at the same period after treatment no live midges were found in any of the treated plots, 25 per cent live were recorded in the untreated.

REINVASION AFTER TREATMENT

Counts of adults made up to 70 hours after treatment indicated that little or no reinvasion of the plots took place. Counts taken in the crop surrounding the trial area at this time showed that activity had decreased markedly.

It is not possible to assess the persistence of toxicity of an insecticide in the

field under conditions of continuous attack by using the figures for the percentage of dead midges recorded, nor when a period of time greater than the possible life span of the individual midge has elapsed since the initial invasion. Dead midges dislodge readily from plants and only if activity ceases and reinvasion takes place at least 4 days or so after the initial attack can reasonably accurate data be obtained.

At Darrington in 1959 a 4-acre field of peas was sprayed on the day of the initial midge invasion with 18 oz of malathion in 30 gal of water per acre; a high percentage kill was obtained and activity in the crop ceased on the following day. Reinvasion took place on the fourth day after the treatment was applied and it was necessary to re-treat. Counts of adults showed a 65 per cent and 93 per cent kill 1·5 and 20 hours, respectively, following this re-treatment. Large numbers of eggs were laid despite 2 applications of a relatively quick killing insecticide under conditions as near ideal as possible. The treatments had been applied within a short time of the appearance of the midges in the crop on the initial and subsequent invasion.

The comparison in yields from this sprayed crop with that from a nearby unsprayed crop of the same variety, sowing date, similar soil type, conditions, aspect and shelter, suggested that the spray treatments had increased yields from 4400 lb to 5600 lb per acre of green peas in pods; an increase of approximately 27 per cent. This would appear to be a slight increase over that obtained by the use of the slower-killing chlorinated hydrocarbon insecticides.

KILL OF LARVAE WITHIN THE TERMINAL SHOOT

Insecticidal action against the adults in the pea crop seemed only partially successful in combating the problem. Consequently, it was decided to investigate the possibility of killing larvae within the terminal shoot and flower buds by using systemic insecticides.

In 1958 the treatments were applied when the majority of larvae were 3-5 days old. In 1959 the materials were applied so that the insecticides would be in the plant tissue at about the time the majority of larvae would be hatching out and starting to feed. Sprays were applied at the rate of 100 gallons per acre with the additions of a small quantity of wetter. Plots 0·01 acres in area were used and 25 infested plants were removed from each plot 5 days or so after treatment.

In 1958 the "heads," flowers and buds were dissected to count any larvae which had not dropped out within 16 hours in the laboratory. Counts were made of live and dead larvae. In 1959 all the plant samples were placed in containers constructed to allow larvae to drop into a lower compartment containing water. A period of about 6 days was allowed to elapse to ensure that all live larvae would become fully fed and drop. The numbers of larvae were very high and counts were made by using a counting grid (Strickland, 1954). The results from the trials in 1958 and 1959 are summarized in Tables 3 and 4, respectively.

The plants in the 1958 trials were not as heavily attacked as those used in 1959. The higher rates of Phosdrin appeared to have had a marked effect on the larvae, but demeton-methyl and dimethoate appeared to be ineffective at the concentrations used in 1958. In practice larvae which had fed for 3-5 days within the terminal shoot before being killed would have already initiated extensive damage, which would be extended by secondary agents. Consequently in 1959 tests were made against the newly hatched or very young larvae. There was still a little adult activity at the time the sprays were applied, but heavy egg laying had occurred 3 to 4 days previously. Some of the earlier

eggs were already hatching. It was hoped that the insecticides would be absorbed into the plants and be effective systemically within the terminal shoot when the majority of larvae would start feeding.

TABLE 3

Effect of Systemic Insecticides against Pea Midge Larvae, 3-5 days old, 1958

Insecticide	Active ingredient *oz per acre*	Mean larvae per plant	Dead larvae *per cent*
Phosdrin	2	7·6	16
Phosdrin	2*	7·0	21
Phosdrin	4	8·2	57
Phosdrin	8	9·5	59
Demeton-methyl	10	9·8	19
Dimethoate	8	5·3	12
Untreated	0	16·0	13

* in 50 gal per acre; others in 100 gal

TABLE 4

Effect of Systemic Insecticides applied to Plants shortly before Larvae Hatched, 1959

Insecticide	Active ingredient *oz per acre*	Mean live larvae per plant	Larval infestation as % of untreated
Phosdrin	4	414	62
Phosdrin	8	440	66
Demeton-methyl	20	512	77
Dimethoate	16	406	61
Untreated	0	668	100

The 1959 results suggest that increasing the concentration of insecticide in the dimethoate and demeton-methyl sprays increased their effectivness to a degree similar to that attained by the Phosdrin treatments. The infestations were heavy and the degree of efficiency of the insecticide treatment was insufficient to make any real difference to the extent of plant damage. A relatively small number of larvae feeding in the terminal shoot can have a marked detrimental effect on the pea plant. The resultant loss in yield depends on the stage of flowering at the time of infestation.

SUMMARY

The use of insecticide treatments in controlling *Contarinia pisi* Winn. in the later-sown green pea crops is discussed. None of the insecticide treatments used was entirely successful and heavy larval infestations were found even when treatments were applied less than 24 hours before midge attack. DDT, dieldrin and diazinon treatments gave significant increases in yields of green peas over the untreated plots in trials on crops in the very early stages of flowering and under conditions of heavy attack.

The effectiveness of the persistent toxicity of insecticides against this pest seems to be largely nullified by the growth habit of the pea plant and the midge behaviour of congregating and ovipositing within the terminal shoot.

Phosdrin, diazinon and malathion kill adult midges more rapidly than most of the chlorinated hydrocarbon insecticides tested. While this effect in itself does not appear to be sufficient to prevent serious infestation and produce spectacular increases in yield, there were indications that diazinon and malathion treatments may give slightly higher increases in yield than chlorinated hydrocarbon treatments. Phosdrin at 4 or 8 oz, demeton-methyl at 20 oz and dimethoate at 16 oz per acre, respectively, applied at high volume about 3 days after the main period of oviposition, all reduced larval numbers but not sufficiently to prevent serious damage and crop loss.

Thanks are due to Dr. J. H. Fidler for criticism of the script; to those farmers in South Yorkshire who co-operated in the work; and to members of the Entomology Department, Lawnswood for their assistance

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PROBLEMS IN THE ROUTINE HOT-WATER TREATMENT OF CHRYSANTHEMUM STOOLS

by J. J. HESLING*

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CHRYSANTHEMUM cuttings free from eelworm, *Aphelenchoides ritzemabosi* (Schwartz), may be obtained from stools which have been immersed for 5 minutes in water heated to a temperature of 115°F. This "short" treatment is claimed to be less damaging to the stools (Staniland, 1950) and has therefore been considered preferable to the "long" treatment of twenty minutes at 110°F.

Some of the equipment used to treat stools is very crude and, even with most careful operation, it cannot hope to achieve the critical control of temperature important for maximum eelworm kill and minimum plant damage. Thus, a commercially made hot-water bath used to treat stools in eelworm experiments proved to be totally inadequate. Holding eight gallons of water, it was heated by a small "cold" gas flame controlled by a capsule-operated thermostat of unknown performance; the capsule and its holder were placed outside the bath, on its wall. The gas flame could not supply enough heat to regain the water-temperature drop when stools were plunged in the bath and there was a maximum variation of 3·9°F in water temperature throughout the bath. A larger commercially made tank, holding thirty gallons of water, was viewed

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on a nursery. Here, a paraffin lamp supplied the heat. The temperature throughout the bath varied by about 3·6°F and when about a quarter of the usual number of stools were put into it, the temperature fell and continued to fall for over fifteen minutes. In both baths there were "hot-spots" in the water immediately above the burners.

With the prospect of hot-water treating several hundred stools for experiments in 1960 the eight-gallon bath was modified. The cooling effect of adding stools was decreased by increasing the capacity to ten gallons and temperature variation was decreased by circulating the water in the tank every 5 minutes by an electric pump delivering 120 gallons per hour. The water was arranged to flow from beneath the heater in the tank base through the pump and into the top of the tank. Thus, mixing was encouraged and there was no need to prime the pump. The water was heated by an electric immersion heater controlled by a thermostat with a differential of $\pm$ 0·18°F about the required temperature of 115°F. The maximum permissible temperature drop on addition of stools was 1°F which was to be recovered in half a minute, i.e., 10 per cent of the treatment time. This last requirement determined the power input.*

Two immersion heaters with a total power output of 3·6 Kw were fitted in the tank. On the 240 volt supply the current taken was about 15 amps, although this was probably exceeded at switch-on, when the heaters were cold and had a lower electrical resistance. The contacts on the thermostat were not designed to carry such a current, but this was overcome by using a hot wire vacuum switch controlled by the thermostat.

PERFORMANCE OF THE BATH

The thermostat was set with the water temperature falling to 115°F; this was measured by a high grade thermometer. The bath was tested several times by heating the water from cold. Fig. 1 shows a typical result and indicates two things. First, the water in the bath rose above the set switch-off temperature as the bath heated from cold, because the thermostat element is insulated by air in a watertight copper sheath and its temperature lagged behind that of the water. Second, the required constant temperature was not achieved, because the thermal lag of the thermostat (as above but not so pronounced when the thermostat and its cover had warmed through) and its differential together with the vacuum switch delay resulted in a total differential which exceeded that required (0·18°F). The rate of temperature increase, 1.75°F per minute, was less than the specified 2°F per minute.

The bath was then tested with washed and drained chrysanthemum stools placed in a warm wire basket which rested on a tripod above the heaters in the bath. The addition of more than twelve stools (the number depends on the size of the stools) caused a drop of over 1°F in the water temperature. If the stools were not agitated in the water, the temperature close to them sometimes failed to return to 115°F in the treatment time in spite of the full circulation provided by the pump. The pump filter occasionally became clogged with rootlets, indicating the need for an impeller-type of pump.

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* 1 British Thermal Unit (B.T.U.)=heat required to raise 1 lb of water 1°F
1 Kilowatt-hour=3,412 B.T.U. 1 gallon of water=10 lb
Assuming no heat loss and 100 per cent efficiency, to raise 1 gallon of water through 1°F in $\frac{1}{2}$ minute requires a power input of

$$\frac{10 \times 120}{3412} \text{ kW} = 352 \text{ watts approx.}$$

Thus a 10-gallon tank required a power input of 3·52kW approx.

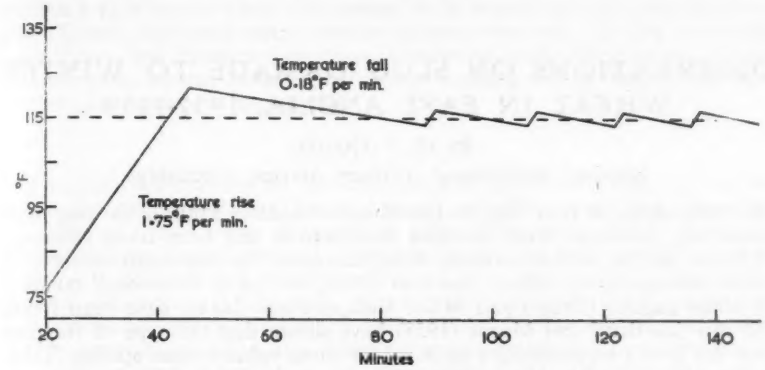

Fig. 1. Temperature control in electrically heated baths.

DISCUSSION

The results show that a power input of approximately 350 watts per gallon of water is required to ensure a sufficiently rapid return to the specified temperature, that even with expensive control equipment it is difficult to maintain close control of the water temperature and that the ratio of stools to gallons of water should not greatly exceed 1 : 1. The routine treatment of chrysanthemum stools at 115°F on a commercial scale by electrical methods would therefore present great technical difficulties. For example, a 30 gallon tank would require a power input of (30 × 350) watts=10·5kW, and at most only about 30 stools could be treated at any time. If 60 stools were treated, the power input would have to be doubled to bring the tank back to 115°F in ½ minute.

It seems that the routine short treatment of thousands of stools on a commercial scale by automatically controlled baths heated by electricity is impracticable. The recommended method of heating the water to a level above the treatment temperature by an amount equal to the temperature drop when the stools are put in the tank must be followed; the success of the treatment then depends on the common sense and skill of the operator.

In theory, there are better prospects for a hot-water bath for routine treatment of stools at 110°F for twenty minutes. If two minutes are allowed for the water to regain 1°F after the stools are put into the bath, 88 watts per gallon of water is needed. An input power of 3 kilowatts would be suitable for 30 gallons of water, in which approximately 36 stools could be treated together; this number could be doubled if 4 minutes were allowed for the water to return to 110°F. These estimates assume that heat loss from a well lagged tank is negligible.

Better control of water temperature could be achieved with a thermostat in closer contact with the water than the one used in these tests, e.g., a capillary type thermostat, and performance would be further improved if the thermostat had direct control of the electrical supply to the heater.

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OBSERVATIONS ON SLUG DAMAGE TO WINTER WHEAT IN EAST ANGLIA, 1957-1959

by H. J. GOULD

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ON arable fields in East Anglia *Agriolimax reticulatus* Müll. is the slug most commonly recovered with standard metaldehyde and bran traps (Thomas, 1948) on the clay soils in autumn. *Arion hortensis* Fer. and small numbers of *Arion circumscriptus* Johnst. can also usually be found. Only small numbers of *Milax gagates* (Drap.) and *Milax budapestensis* Hazay. have been found but van den Bruel and Moens (1958) have shown that this type of trapping may not give a representative catch of the more subterranean species. Table 1 gives the percentage of each species in the catch on five fields on the dates shown.

TABLE 1

Species of Slugs found on Five Fields using Metaldehyde and Bran Traps

Year	Soil type of field	Date	*Total No. of slugs collected*	Percentage of each species				
				Agriolimax reticulatus	*Arion hortensis*	*Arion circumscriptus*	*Milax gagates*	*Milax budapestensis*
1956	Silty Clay	Sept 4	384	95	–	5	–	–
		Sept. 19	370	100	–	–	–	–
1957	Silty Clay loam	Sept. 27	70	90	8	2	–	–
		Oct. 10	142	18	80	2	–	–
1958	Clay loam	Sept. 24	485	94	4	2	–	–
1958	Clay loam	Oct. 4	392	95	–	5	–	–
1956	Heavy Silt	Nov. 10	171	20	70	2	7	1
		Nov. 17	500	26	66	2	5	1

These results support other field observations. When looking for hollowed grain on fields where underground damage has occurred *Agriolimax reticulatus* is usually the only species found in large numbers. All the species mentioned above can probably cause damage to autumn sown wheat.

It is well known that slugs are most likely to be serious pests on heavy land and records of damage in East Anglia show certain areas where loss of winter wheat most usually occurs. In 1957 and 1958 reports of slug damage were received from at least 140 farms. The locations of these farms is given on the soil map (Plate I, 1) which shows roughly the areas of clay loam type soils. Slug damage occurs mainly on the clay soils of south-west Cambridgeshire, south Huntingdonshire, Essex and East Suffolk. There were also many reports from the Wisbech area in the Isle of Ely and north-west Norfolk but these were all from farms on the heavy silts or silty clay loams. No reports of damage to winter wheat were received from the fen peats and sandy areas.

In 1953, following a large number of complete failures of winter wheat in East Anglia, it was found (Brown, 1955) that underground damage to the seed (Plate I, 2) could take place soon after drilling and before germination.

Serious loss of winter wheat also seemed to be associated with previous cropping (Brown, 1955) and many complete failures were seen after dry harvesting peas, clover and brassica seed crops. Conditions under these crops or their residues often appear to be ideal for slug breeding during August and September, particularly in wet seasons.

SURVEY IN 1957

To obtain information on the importance of grain hollowing and on the effect of previous cropping, District Agricultural Officers were asked to report all fields of winter wheat damaged by slugs which were visited during the course of their normal advisory duties during the last three months of 1957. From each field details were obtained of soil type, previous cropping and the type of slug damage taking place, such as grain hollowing, shoot grazing and leaf shredding. Patches caused by underground feeding are often extensive and may require redrilling. It is difficult to make quantitative measurements of this damage, but to obtain some information during this survey a visual estimate was made of the area of the bare patches associated with underground damage and also of the overall loss of stand on all fields visited. Reports were completed for 132 fields from 105 farms in Cambridgeshire, the Isle of Ely, Essex and Huntingdonshire, covering over 2,000 acres of winter wheat.

Information on soil type was given for 124 of the fields visited; 95 were classed as heavy clay loam and 29 as organic silty clay loam. Table 2 gives a summary of the reports, with details of previous cropping.

TABLE 2

Summary of Reports on Fields of Winter Wheat damaged by Slugs in 1957

Previous crop:	Dry harvesting peas	Clover	Other leys	Beans	Cereals	Brassica seed	Full fallow	Potatoes	Sugar beet
No. of fields in survey ...	24	39	17	14	21	14	2	1	0
No. redrilled	14	14	9	8	10	5	0	0	0
Percentage redrilled ...	58	36	53	57	48	36	0	0	0

It was not possible from these data to say with certainty that damage to winter wheat was most likely after a particular crop, as the results might only indicate which crop wheat was most likely to follow in the heavy land areas concerned. No complete information is available for crop rotation in these areas in 1957, but limited data on previous cropping were obtained for all fields of winter wheat being grown on 20 of the farms (70 fields) visited in the survey. This together with information from other surveys in 1955 and 1956 (unpublished data from eyespot and take-all surveys kindly supplied by Mr. H. T. E. Smith), shows that about 20 to 25 per cent of the winter wheat acreage may be expected to follow potatoes, sugar beet, or fallows.

The majority of reports of damage were on winter wheat following clover, dry harvesting peas and cereals, while there were exceptionally few reports of damage after fallows, potatoes, sugar beet, or vining peas.

Redrilling or extensive patching was necessary on 60 of the fields, involving some 900 acres. Grain hollowing was recorded as the most important single factor for loss of stand on 61 of the fields, 41 of these needed redrilling or patching.

SURVEY IN 1958

In 1958 District Advisory Officers were asked to complete a survey form giving details of soil type, previous cropping, seedbed conditions and the nature and extent of slug damage for all fields of wheat on any farm where at least one field was damaged by slugs.

Information was collected for 92 fields (approximately 1,400 acres) from 36 farms. All these fields were drilled in October or early November. The number of reports was smaller than expected considering the wet summer, but this was probably partly due to the smaller acreage of winter wheat drilled on heavy land because of the exceptionally bad drilling conditions.

Information on soil type as in 1957 merely confirmed the association between slug damage and heavy soils. The number of fields of each soil type in the 1958 survey visited on different soils, and the numbers of these in which slug damage was recorded, were:

	Clay loams	Silty clay loam	Silty loam	Peaty loam
No. of fields in survey	33	44	11	4
No. with slug damage	26	28	3	0

One of the main aims of the 1958 survey was to obtain further evidence of any relationship between the previous crop and slug damage to winter wheat. Table 3 summarizes the data obtained in 1958. Although the data are limited, the results are similar to those obtained in the 1957 reports and they suggest that damage most frequently occurs when winter wheat follows dry harvesting peas or beans, clover or grass leys, brassica seed crops and cereals and is less likely after fallows, potatoes and sugar beet.

Slug damage was assessed visually as in 1957 and was recorded to some extent on 57 of the 92 fields. On 48 of these grain hollowing and shoot grazing were both recorded and grain hollowing was considered to be mainly responsible for loss of stand on at least 36 of the fields. The range of the visual estimate for the loss of stand on damaged fields (Table 3) gives some information on the severity of the attack, the mean percentage loss of stand on fields visited following peas, leys or brassica seed being 30, 20 and 55 per cent, respectively. Redrilling or patching was necessary on 28 of the fields. Some leaf shredding was recorded on all fields, but on only 12 of these was it thought to be of importance at the time of the visit.

It has often been noted that slug damage seems most severe on fields or parts of fields where the seedbed tilth is exceptionally rough and cloddy. Traditionally a rough seedbed is considered desirable for autumn-sown crops on heavy land. It was interesting to see from the description of seedbed conditions given in the reports, that on fields where wheat followed potatoes seedbed tilth was invariably considered to be fine. Unfortunately, too few fields were seen to make comparisons of the extent of slug damage on fields with different seedbed conditions but similar previous cropping. Other than where wheat followed potatoes, details of seedbeds were given for 48 fields; 20 of these were considered fair or good and 28 very rough and cloddy. The average overall estimated loss of crop on the fields with a good seedbed was 8 per cent with 2 fields needing redrilling or patching; and on those where the seedbed was obviously rough and cloddy 31 per cent with 16 fields needing redrilling or patching.

TABLE 3

Summary of Reports on Fields of Winter Wheat damaged by Slugs in 1958

Previous crop:	Dry harvesting peas	Clover and grass leys	Beans	Cereals	Brassica seed	Full fallow	Potatoes	Sugar beet
Total no. of fields in survey ...	23	23	3	5	15	2	16	5
Acreage	330	380	36	80	250	20	263	74
No. of fields with slug damage ...	22	14	3	5	11	0	2	0
No. of fields redrilled or patched ...	14	2	1	2	9	0	0	0
Range of estimated percentage loss of stand on damaged fields	20–90	5–70	5–35	15–70	5–90	0	5	0

On 30 of the fields where slug damage was recorded the headlands were considered to be normal or to have only slight damage; only one field had a patch on the headland where the crop had failed.

Several fields were also seen during the surveys where extra cultivation or consolidation after drilling had apparently reduced the slug damage. For example, on one 18 acre field where wheat followed clover the crop was a failure, except for about 2 acres where the stand was reasonably good. This area had received a second harrowing immediately after drilling, but rain had prevented the whole field having the same treatment. On another field where wheat followed clover the crop was very thin except for regular bands across the field corresponding to the wheelings of a tractor used to apply bait the day after drilling.

Baits based on metaldehyde or Paris green and bran, the standard recommendation for slug control, had been used on 24 of the fields where slug damage occurred. On eleven of these fields proprietary pelleted baits had been used. Although underground damage after drilling has been shown to be the most usual cause of loss, these baits were invariably applied after brairding, when the damage had already taken place. Paris green and bran had been drilled with the seed on three of the fields; 2 of which were after clover and 1 after peas. Only slight damage by slugs was recorded but no control strips were left for comparison.

SURVEY IN 1959

Slugs were difficult to find in the autumn of 1959, even under dry harvesting pea haulm and clover leys. Table 4 gives the total nightly catch of slugs on the same field in Cambridgeshire in three years on the dates shown, using metaldehyde and bran traps after cultivation.

TABLE 4

Total Catch of Slugs under 25 tiles in the same Field, 1957-59

1957 Previous crop: Peas			1958 Previous crop: Winter wheat			1959 Previous crop: Spring wheat		
Date	Min. night temp. °F	No. of slugs	Date	Min. night temp. °F	No. of slugs	Date	Min. night temp. °F	No. of slugs
Nov. 1	42	156	Nov. 4	46	392	Oct. 29	38	0
Nov. 20	40	115	Nov. 11	33	246	Nov. 6	29	0
			Nov. 19	31	202	Nov. 20	28	0
						Dec. 9	39	12

No reports of slug damage to winter wheat were received from any area in East Anglia in 1959. The absence of damage and small number of slugs was clearly related to the prolonged dry summer (Carrick, 1942), representative figures for the total rainfall for July, August and September in the areas concerned being approximately 3 in. in 1959, compared with 8.5 and 9 in 1957 and 1958 respectively.

SUMMARY

The surveys have shown that in certain years, particularly after wet summers, slugs can be a serious problem on winter wheat in the heavy land areas. Underground damage by grain hollowing is usually one of the most important causes of failure and the most difficult to control with existing materials and methods. There is good evidence that damage is most likely when winter wheat follows dry harvesting peas, leys, cereals and brassica seed crops, damage seems less likely after fallows, potatoes or sugar beet. Seedbed conditions may also be related to the extent of slug damage, which often seems more severe where the seedbed is very rough and cloddy.

I would like to thank the many District Advisory Officers who took part in these surveys, and also Dr. H. C. Gough and Mr. E. B. Brown for their help and suggestions, and Mr. W. E. Dant for the photograph.

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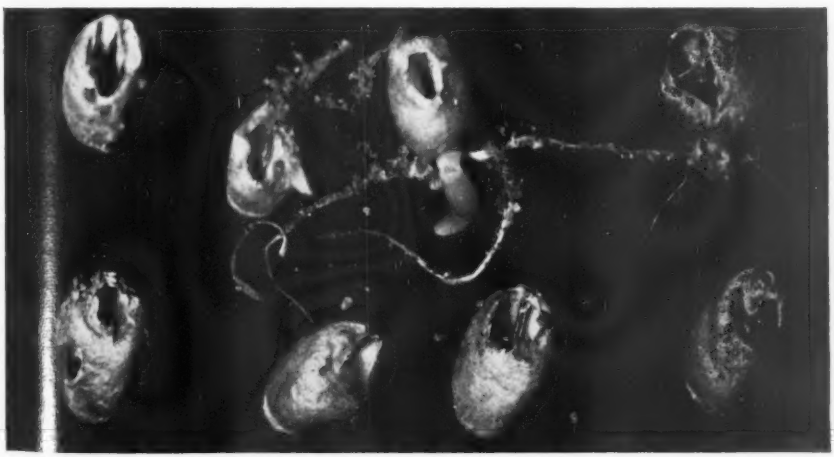
SLUG DAMAGE TO WINTER WHEAT

1. Location of fields in which damage was found. *(Shading based on a soil map by Farm Economics Branch School of Agriculture, Cambridge).*



2. Slug damage to wheat seed soon after sowing.

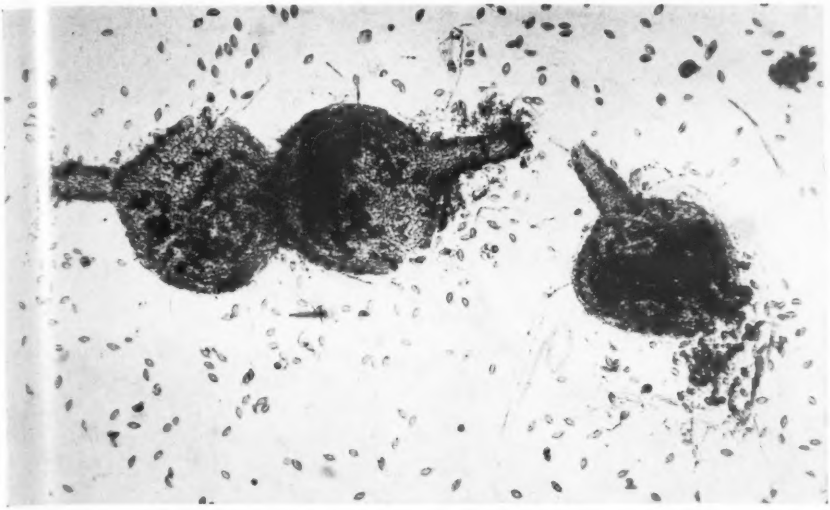
BUD-ROT OF CULTIVATED HAZEL (see p. 167)

(*Photo: East Malling Research Station*)

Part of severely-affected cobnut bush in spring, showing a high proportion of non-foliating buds rotted by *Gloeosporium* sp.

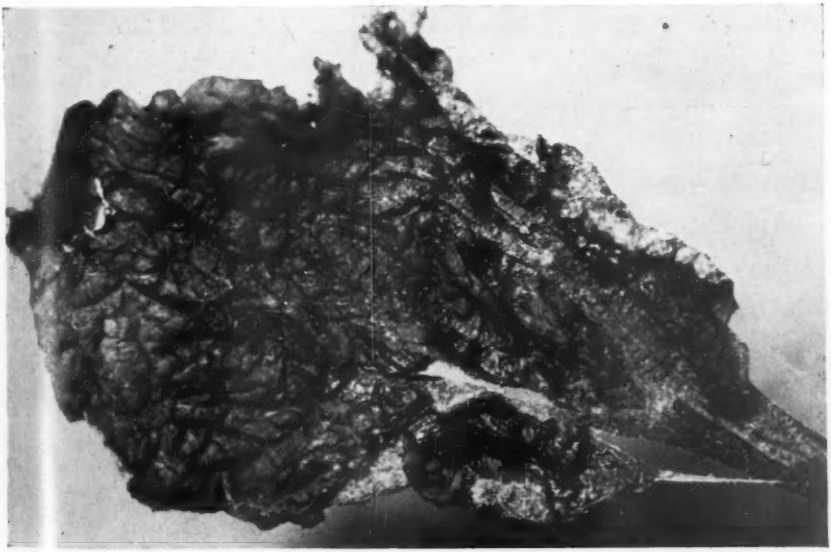
PLATE II

MELANOSPORA DAMNOSA ON CEREALS (see p. 168)



1. Perithecia and ascospores of *Melanospora damnosa.* × 90

EELWORM IN CINERARIA (see p. 166)



2. Leaf distortion caused by *Aphelenchoides ritzemabosi.*

TULIP BREAK IN 'PRIDE OF HAARLEM'

1. Dark break, Grade 2.

2. Light and dark break, Grade 3.

3. Light and dark break, Grade 4.

(*Photos: University of Bristol*)

4. Severe full break, Grade 5.

PLATE IV

TULIP BREAK IN 'PRIDE OF HAARLEM'

by T. E. T. BOND

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IN many varieties of tulip there are two forms of " break "; a self or dark break involving a localized intensification in the anthocyanin coloration, and a light or full break involving its destruction. It has been found by van Slogteren (1959) that these two forms of break are the result of infection by two distinct but never entirely separable viruses or virus strains. This is well exemplified by the variety ' Pride of Haarlem ' in which the symptoms range from a scarcely discernible dark break in plants of otherwise normal appearance and vigour (Plate IV, 1) to a very pronounced light break in plants which are obviously stunted and diseased (Plate IV, 4).

Over the years 1950 to 1958 the incidence of breaking was recorded in a stock of ' Pride of Haarlem ' tulips maintained in beds at Bristol. The original stock of bulbs was obtained from a planting in Sheffield in which there had been a heavy but spontaneous occurrence of flower break in 1949. At Bristol, the bulbs were closely planted in rows 1 ft apart in well manured beds, without fertilizer. A different position in the garden was used each year. The soil was a heavy clay loam. Tulip fire (*Botrytis tulipae*) was troublesome, necessitating regular spraying with captan. No insecticidal sprays were used in any of the years. Surface cultivation was kept to a minimum and handling of the plants during recording or other operations was avoided as much as possible. After flowering, the plants were allowed to die down naturally except for breaking off unripe seed pods. All bulbs were lifted individually for replanting in the following year, whether or not they had flowered. They were sorted on the basis of the season's records, keeping the progenies of the different categories separate. Repeated each year, this led to the establishment of a large number of lines of known history. Until 1954, all bulbs with a diameter of at least 6 cm were replanted; subsequently, a limit of 5 cm was taken, grading for diameters of 5-7 cm, 7-10 cm and over 10 cm. For convenience, the different sizes in each category were planted in separate rows.

GRADING FOR FLOWER BREAK

It was found that foliage symptoms and plant vigour were not amenable to accurate assessment, but the degree of breaking in the flowers could be defined with some confidence as follows:

1. Flowers entirely normal; no dark or light break detectible after close examination.
2. A dark break, inconspicuous and easily overlooked, with at most a very slight tendency to light break in one or two petals only, towards the base or at one edge (Plate IV, 1).
3. More or less generalized light and dark break, the light break in the form of narrow streaks or areas of flecking rather than of discrete or well-defined sectors (Plate IV, 2).
4. Pronounced light and dark break with generally well-defined areas of white covering 20-50 per cent of the total area of the petals. The petals may appear either " flamed " (coloured mainly from the base) or " feathered " (white from the base, the coloured areas extending inward from the margins) (Plate IV, 3).
5. Severe, very pronounced light break affecting more than 50 per cent of the area of the petals. The overall size of the flowers is reduced; the ovary may be aborted, and development of the whole plant is poor, almost invariably with mottling of the leaves (Plate IV, 4).

RECORD OF BREAKING OVER NINE YEARS

In each year, a count was made of the number of blooms exhibiting each degree of breaking as defined by the above key. The results were entered in detail on a plan of the beds, so that each plant was identifiable later when the bulbs were lifted. The count was made on one occasion only each year, when the beds were in full bloom, and if possible in full sunshine. Colour photographs were taken to assist the recording and to check consistency in judgment of the grades from year to year. The average break grading, and the percentage of the blooms showing each grade of breaking in each year, was as shown in Fig. 1.

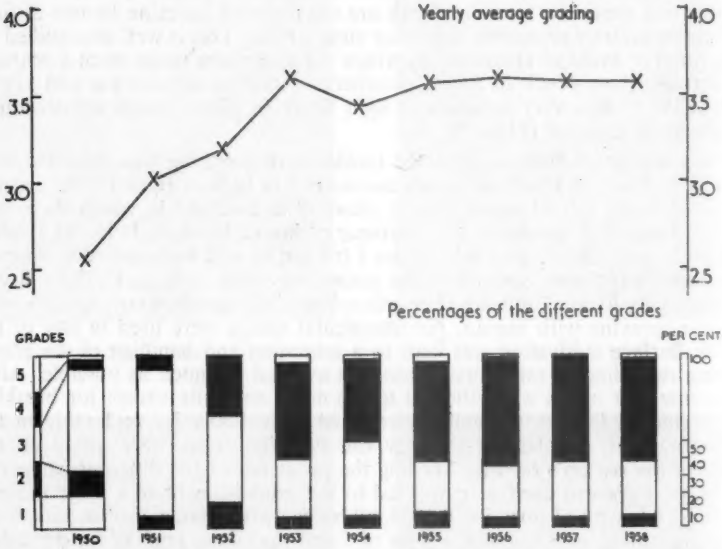

Fig. 1. Yearly average grading for tulip break, and percentage of blooms showing each grade of breaking, in a stock of 'Pride of Haarlem' at Bristol, 1950-58.

The average grading for flower break in the whole population of plants rose from 2·6 in 1950 to a maximum of 3·6 in 1953, and thereafter it remained fairly steady, with about 90 per cent of the blooms in grades 3 and 4. These two grades cannot easily be distinguished (see Plate IV, 2 and 3) and taken together they seem to be the expression of infection by a balanced proportion of the two virus strains as described by van Slogteren (1959). They represent the more or less stable (and not unattractive) degree of flower break to which this variety tends. The balance is maintained in part by the dying out of the more severely affected grade 5 stock.

Grade 1 flowers, apparently free from infection, were present only at the initial record, in 1950; when there were eleven of them out of a total of 56. By 1953, this stock had increased to produce 27 flowers with an average grading of 3·7 (11 grade 3, 14 grade 4, and 2 grade 5).

Of the progeny of bulbs which produced grade 2 flowers in 1950, the great majority soon produced flowers in grades 3 and 4; but the descendants of one of these bulbs remained consistently in grade 2 for the whole period of nine years.

EFFECT OF FLOWER BREAK ON MULTIPLICATION

The stock as a whole increased from 56 flowering bulbs in 1950 to a maximum of 509 such bulbs in 1956, with a slight decline thereafter. Unfortunately, the experiment provided no comparable figures for a healthy stock of the same variety not exposed to infection. There was a general tendency for the bulbs showing the higher grades of flower break to produce a smaller total weight of progeny per bulb, of a smaller average size, so that these stocks tended to die out within a few years. A study of the records for the severely affected grade 5 stock in its first four years showed an average rate of decline of 54 per cent.

SUMMARY

Symptoms of tulip break in a stock of 'Pride of Haarlem' Darwin tulips at Bristol were recorded annually from 1950 to 1958 in five arbitrary numerical grades according to their degree of severity, from grade 1 (apparently healthy) to grade 5 (severe light break affecting more than 50 per cent of the total area of the petals).

The average grading rose from 2·6 in 1950 to a maximum of 3·6 in 1953 and thereafter remained fairly constant, with about 90 per cent of the flowers showing severe break in grades 3 and 4. No lines remained in grade 1 after the first year; and only one line remained consistently in grade 2. Lines in which grade 5 was reached tended to die out within a few years, whereas the stock as a whole increased about ten times.

I am indebted to Mr. F. Senogles, Miss F. G. Davies, Mr. R. R. Stapleton and Mr. P. R. Thoday for their assistance, successively, in growing the bulbs; and to Mr. D. H. G. Leathers for taking the photographs.

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SUGAR BEET YELLOWS IN GREAT BRITAIN, 1960

by R. HULL

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WARM dry weather for the first half of 1960, followed by a wet summer and autumn, favoured the growth of sugar beet, and the British crops gave the highest average yield so far: 17·37 tons per acre of roots at 14·97 per cent sugar content—a calculated sugar yield of 2·60 tons per acre.

Many plants infected with sugar beet yellows virus persisted through the mild winter of 1959-60 and large populations of *Myzus persicae* and *Aphis fabae* which developed on spring hosts threatened to spread yellows from these sources to young sugar beet crops. However, aphids which started to infest sugar beet in mid-May increased slowly because of attack by numerous predators and parasites. They were also controlled by spraying, and yellows, although widespread, developed late. An average of 0·6, 4·6, 16·5 and 27·3 per cent of plants had yellows at the end of June, July, August and September, respectively, in 145 fields sampled by the agricultural staff of the British Sugar

Corporation. The percentage of 413,000 acres of sugar beet with under 1 per cent of infected plants at the end of August was 12·5; with 1-20 per cent, 52·4; with 21-60 per cent, 29·1; and with over 60 per cent, 5·8. The mean percentage of plants with yellows at the end of August calculated from these data was 21·7.

Yellows caused the following calculated losses in 1960 (cf. HULL, *Plant Pathology*, 1960, **9**, 151-2):

Calculated Percentage loss of Sugar Yield		Actual Yield per Acre		Estimated Potential Yield of Roots* per Acre	Estimated loss of Root Yield*
A†	C†	Sugar	Roots*		
		tons	*tons*	*tons*	*tons (000)*
7·1	8·2	2·60	16·25	17·49	516

*Converted to equivalent yield at a sugar content of 16 per cent.
†A: Assuming 4½ per cent loss for each week the plants show symptoms. C: Assuming 2.15 cwt per acre loss for each 10 per cent of infected plants at the end of August. (Calculated from yellows incidence and factory yields, 1946-57.)

The calculated percentage loss of sugar yield was similar to that of the previous two years, but because the actual yield was larger, the calculated loss of root tonnage was greater. The percentage loss (7·1 per cent) compares with 19·3 and 19·6 per cent in 1957 and 1949, respectively, when yellows was severe and with less than 5 per cent in 1946, 1947, 1951 and 1953-56 inclusive.

The sugar factories advised growers when to spray to control yellows on the basis of daily counts of aphids on sugar beet. Spray-warning cards were sent out in a few areas in the third week of May and in most areas in the first week of June. By mid-June growers in all areas except north Lincolnshire and Yorkshire had been advised to spray, twice in many areas. Of the 216,500 acres sprayed, 34,100 were sprayed in May, 157,200 in June and 25,200 in July: 48,200 acres were sprayed twice and 2,800 three times. Less acreage was sprayed than in 1959 but considerably more than in earlier years. Organophosphorus insecticides are the most effective for controlling yellows and are generally used by growers. Data collected by the fieldmen of the British Sugar Corporation on the use of various insecticides are summarized below:

Approximate Acreage of Sugar Beet Sprayed against Aphids at Least Once.

1955	*1956*	*1957*	*1958*	*1959*	*1960*
24,000	Few	103,000	101,000	350,000	217,000

Acreage Sprayed with Various Insecticides

	1955	*1960*
Demeton-methyl	19,000	149,000
Dimethoate	—	54,000
Other organo-phosphorus compounds	4,000	7,000
Fluoroacetamide	—	2,000
Other compounds	1,000	4,000

The usage of various insecticides on sugar beet has been discussed more fully by R. A. Dunning (*J. Soc. chem. Ind., Lond., in press*).

Timely spraying in 1960 generally decreased yellows incidence and in most areas the contrast in colour between sprayed and unsprayed crops was obvious in the autumn. By the end of the season, yellows was more prevalent in some areas in the south, west and north than in East Anglia—the reverse of the usual distribution. This may be partly the result of spraying. For instance, in north Lincolnshire only 19 per cent of the acreage was sprayed and yellows incidence at the end of September was 60 per cent. In Norfolk and Suffolk 80 per cent of the acreage was sprayed and yellows incidence was 20-27 per cent.

SPRAYING PRACTICE AND THE CONTROL OF APPLE SCAB ON COX'S ORANGE PIPPIN AND BRAMLEY'S SEEDLING IN ENGLAND, 1958-60

Contribution from the Conference of Plant Pathologists, National Agricultural Advisory Service, compiled by T. F. Preece, of the Plant Pathology Laboratory, Harpenden.

THE successful control of apple scab on Bramley's Seedling under difficult conditions in the Wisbech area during the years 1953-55, by the application of mercury sprays as quickly as possible after the occurrence of Mills periods in the spring and starting at bud-burst (Storey and Ives, 1956), showed the need for investigation of the possible advantages of this method of spraying in other English apple growing areas, where protective applications of sulphur and other fungicides, timed in relation to bud stages (Anon, 1946), had become traditional.

By 1957 the part of the investigation concerned with the study of apple scab infection weather (Preece and Smith, 1961) had shown that the principal Mills periods occurring in English apple-growing areas could be determined without great difficulty. It was then necessary to review the *actual* spraying practice in the several areas, and to study the relative effectiveness of the differing spray programmes in use, in order to see the extent to which these programmes might be improved by better timing of the applications in relation to infection weather.

For the purpose of this "spray practice" survey growers were asked to record the dates of their applications, and particulars of the materials used, on a specially prepared calendar card. Growers were also asked to give other relevant information, including the acreage of the orchard, the variety, age and type of trees, the dates of bud-burst, pink bud and petal fall and the dates on which scab was first seen in the orchard, on leaves and on fruit. Horticultural Advisory Officers helped in the completion of the cards and also in their distribution and collection. A Mills-period table (from Mills and LaPlante, 1954) was provided and those growers making Mills-period observations were asked to ring dates on their calendar card to show the days on which they considered such periods to have occurred. At picking time the survey orchards were visited by Regional Plant Pathologists, who assessed the amount of scab on the foliage and fruit, using the standard key of Croxall, Gwynne and Jenkins (1952).

The survey was limited to Cox's Orange Pippin, as the most widely grown dessert variety, and to Bramley's Seedling among the culinary varieties. The representation in the survey of the several principal apple-growing areas in the country (see Fig. 1) was as shown in Table I. In all, 743 spray programmes were examined during the three years of the survey, of which 506 were for Cox's Orange Pippin and 237 were for Bramley's Seedling.

The individual programmes varied greatly, both as regards materials used and times of application. Details of individual programmes cannot be presented here, but the general pattern of spray usage as shown by each year's survey is represented graphically in Figs. 2, 3 and 4. In these diagrams the programmes for Cox's and for Bramley's are analysed separately; and the histograms for each week, from mid-March to the end of July, represent the number of

orchards out of the total number stated which received a spray application in that week. Thus in Fig. 2, for 1958, in the week which included the last few days of April and the first few days of May, 90 of the 141 Cox's orchards had a spray application, and of these 90 spray applications 47 were sulphur, 30 captan and 13 mercury. To avoid complication of the diagrams, mixed sprays of mercury and captan are shown as "mercury", and mixed sprays of captan and sulphur are shown as "captan". Not all the spraying records were suitable for inclusion in the histograms, but Figs. 2, 3 and 4 present the data from 662 programmes. In all three years of the survey, sulphur (as lime sulphur, wettable sulphur or colloidal sulphur), captan and organo-mercury sprays were the three fungicides most widely used for scab control. A very few growers used ziram or thiram post blossom, and many used Karathane for the control of mildew, but these applications are not represented in the diagrams.

To provide some indication of the way in which the pattern of spraying was related to infection weather and to bud stages, Mills periods and the times of bud-burst and pink bud are shown on the diagrams for each year. The marks for Mills periods indicate times at which Mills conditions were widespread (as shown—for March to the end of May—by the charts in Preece and Smith, 1961) and they are based on all available records, including the growers' observations.

Fig. 1. Distribution of apple growing in England and Wales (all varieties except cider apples), 1957

TABLE 1

Representation of the Main Apple-growing Areas in the Surveys, 1958-60

Region	County	Apple acreage *		Number of spray programmes examined	
		'000 acres	*per cent of total*	*No.*	*per cent of total*
S.E.	KENT	48	43	139	19
	Others	12	9	173	24
W. Mids	WORCS	7	6	102	14
	HEREFORD	5	5	64	9
	Others	4	4	74	10
E	CAMBS	4	4	46	6
	NORFOLK	7	6	43	6
	ESSEX	11	10	24	3
S.W.	SOMERSET	3	3	38	5
	GLOS	5	5	19	3
	Others	5	5	9	1
All regions		111†	100	743	100

* From Fruit Census, 1957.
† Includes 12 programmes in the Yorks and Lancs, and East Midland Regions.

With three exceptions (in 1960) all the commercial orchards examined throughout the survey were sprayed for scab control. In 1958 about 22 per cent of the orchards received 1 to 4 applications; 63 per cent received 5 to 9 applications, and 15 per cent had over 10 applications during the season. These proportions were much the same in 1959 and 1960 (Table 2).

TABLE 2

Percentage of Orchards in Survey which received 0, 1-4, 5-9, and 10 or more Applications of Fungicides for Scab Control, 1958-60

Number of applications	1958	1959	1960	Mean 1958–60
None	0	0	1	—
1–4	22	16	15	18
5–9	63	61	57	60
10 or over	15	23	27	22

Over the three years of the survey high-volume spraying (at 100 gal per acre or more) was employed in 52 per cent of the orchards surveyed. Low-volume spraying (at 35-50 gal per acre) was employed in 34 per cent of the orchards; and in a very few of the orchards (38 out of 789 in all) " concentrate " spraying (at 1-5 gal per acre) was used.

One unexpected finding from the survey in 1958 (Fig. 2) was the usage of mercury on Cox's Orange Pippin. Of the Cox's programmes examined in this year 27 per cent included at least one mercurial application, generally at or near

bud-burst or before pink bud. The diagram also shows that on Cox's over half of the programmes included captan at some time before the end of May. There was much usage of captan after this date, but some of this was for the control of *Gloeosporium* rather than scab. Of the Cox's programmes 20 per cent used sulphur only, often starting with strong 2½ to 3 per cent lime sulphur pre-blossom and changing to wettable or colloidal sulphur for post-blossom applications—partly for scab control and partly against mildew. Complete programmes using mercury only or captan only were very few on Cox's. The general picture for Cox's (Fig. 2) was of " blanketing " the trees with fungicide (chiefly sulphur or captan) throughout the season, with very little regard either to bud stages or to infection periods.

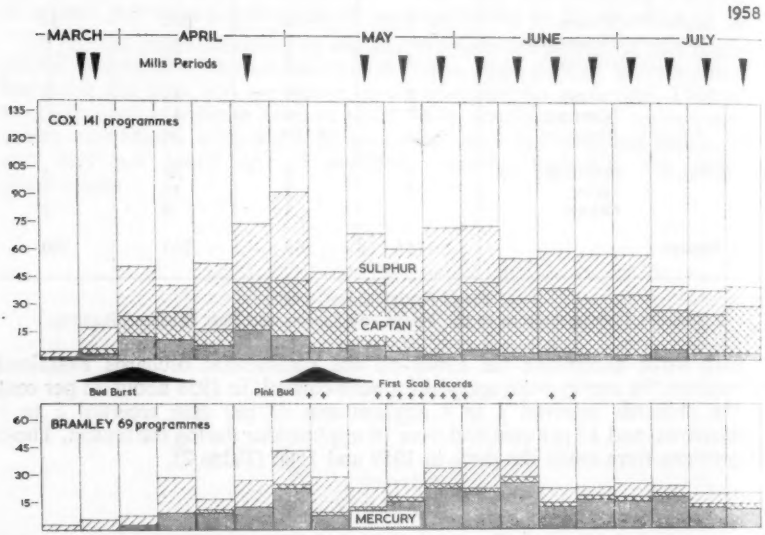

Fig. 2. Applications of fungicide each week in relation to bud stages, infection periods and first scab records (all districts) 1958.

On Bramley's Seedling (Fig. 2, lower diagram) the pattern of spraying was quite different. For this variety complete programmes using mercury throughout the season were the most frequent choice; there was a tendency for these sprays to be applied when the first scab lesions were seen.

In 1958 the general level of scab was very low. Half the orchards in the survey had no scab at all, either on foliage or fruit. About 44 per cent had less than 1 per cent of the fruit scabbed, and in only 11 of the orchards was there more than 1 per cent of the fruit scabbed. Three of these were small mixed orchards in Yorkshire, two of them unsprayed until after mid-May. Two, in Worcestershire, had no application before or within four days of the first infection period. Two, in Hampshire, had two applications only, both of which were badly timed. The other orchards with over 1 per cent of scabbed fruit were similar, either with very few applications or timing which clearly could not have covered infection weather. In 5 of these 11 orchards the trees were over 50 years old. Four of them were sprayed at low-volume, and one was " concentrate sprayed " with lime sulphur at 5 gal per acre.

In 1959 (Fig. 3) bud-burst was earlier than usual and there were infection periods at the end of March, but the general picture of spray application differed little from that in 1958 (Fig. 2). There was rather more use of captan in 1959.

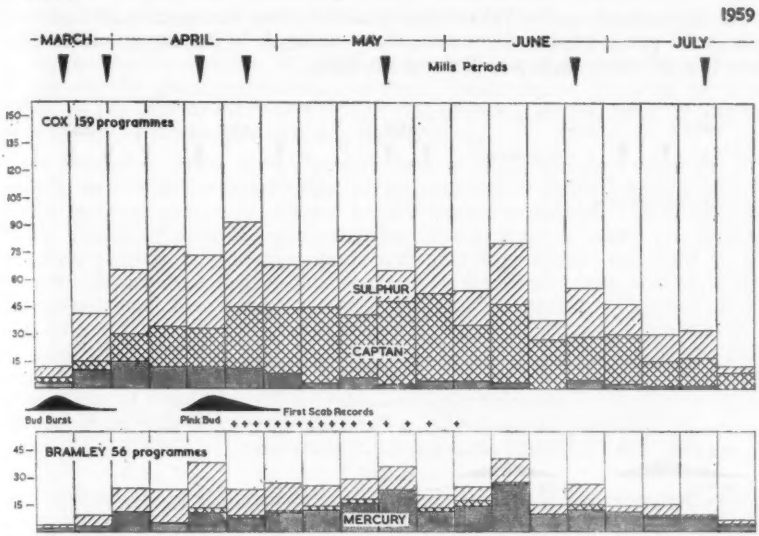

Fig. 3. Applications of fungicide each week in relation to bud stages, infection periods and first scab records (all districts), 1959.

As might have been expected from the widespread early infection periods in March and April there was more scab in 1959 than in 1958. Many of the first lesions, however, were at the calyx end of the fruit and involved only the sepals. The summer months were very dry in 1959 and in many orchards there was no visible change in the amount of scab on the fruit after mid-June. At picking time it was generally difficult to find any scab on the fruit without close inspection. 47 per cent of the Cox orchards and 32 per cent of the Bramley orchards had no scab at all, either on fruit or foliage.

In 1959, however, a number of Bramley orchards in Kent were brought into the survey for the first time, and in this particular group of 28 orchards there was sufficient scab to provide some indication of the effect of spray timing on the eventual amount of scab on the fruit. Thirteen of these orchards had little or no scab on the fruit, and of these 13 orchards 10 had a protective spraying during or within 3 days before the beginning of the infection period at bud-burst, or an application of mercury or 3 per cent lime sulphur within 4 days after it. Of the 15 orchards out of the 28 in which there was much scab (on average 7 per cent of the fruit scabbed) only 4 had similar cover over the first infection period. This was the principal difference to be found in the spray programmes of the scabby and clean orchards. Both groups had much the same spray cover for the infection periods occurring at pink bud, and both had about the same number of spray applications (on average 5 up to the end of May and 9 during the whole season).

Study of the spray programmes for 10 other orchards in which there was an appreciable amount of scab on the fruit (5 in the West Midlands. 3 in the

Eastern and 2 in the South-western region) showed a similar poor timing of spraying in relation to the first infection period of the year. None of these 10 programmes included useful action to cover the March infection weather, and only 5 of them had cover for the infection period at bud-burst.

All the orchards in the 1959 survey in which there was much scab had trees at least 25 years old; but there were many orchards in the survey much older than this in which there was little or no scab.

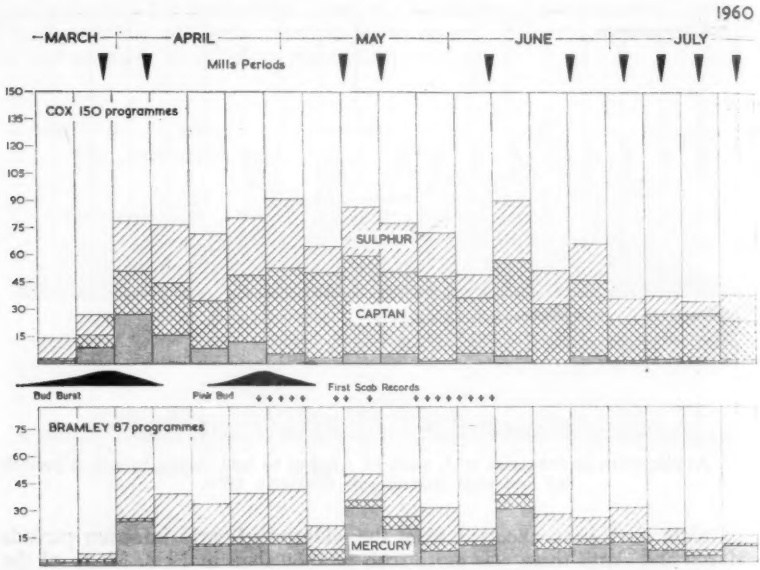

Fig. 4. Applications of fungicide each week in relation to bud stages, infection periods and first scab records (all districts), 1960.

In 1960 (Fig. 4) on Cox's Orange Pippin there was the same general picture of spray "blanketing" as in 1958 and 1959, but with a further increase in the use of captan. The diagram for the Bramley orchards, however, shows a generally improved timing of spray applications in relation to infection periods —not only at bud-burst but also in mid-May and early June. An analysis of the amount of spraying done in 1960 with each of the several fungicides now used for scab control is given in Table 3.

Except in Kent, where infection periods were unusually prolonged at petal fall, there was less scab on the fruit in 1960 than in either 1958 and 1959. Eighty per cent of the Cox and 60 per cent of the Bramley orchards had no scab at all on the fruit. Of the whole 248 orchards included in the 1960 survey only 7 had over 10 per cent of the fruit scabbed, and of these 6 were in Kent. There were 60 orchards with about 1 per cent of the fruit scabbed, and of these 31 were in Kent.

DISCUSSION

The many spray programmes examined in this survey have clearly indicated that most of the spraying against apple scab in England is done at regular intervals, in an attempt to maintain a fungicidal cover on fruit and foliage,

irrespective of bud-stages or infection periods. There was, however, some notable improvement of spray timing in relation to infection periods on Bramleys in 1960.

The low level of scab in the three years of the survey (Preece, 1961) made it impossible to obtain clear-cut evidence of benefit from spray timing according to infection periods; but where scab control obviously failed, poor timing or an inadequate number of applications in the spring were the principal causes. Of the spray programmes for the 43 orchards, in the three years, in which 10 per cent or more of the fruit was scabbed, no less than 39 showed poor timing or inadequate spraying in the spring.

On Bramleys, where many growers tend to apply mercury when the first scab is seen, a better distribution of the spraying to cover infection periods earlier in the season would almost certainly improve control. The position on Cox's Orange Pippin is more complex. Many growers cover all possible infection periods by intensive protective spraying. About one-third of the growers already use organo-mercury sprays on Cox's near bud-burst and they could time these sprays according to infection periods. The real service that information about infection periods can give to Cox growers, however, is to focus their attention upon certain critical days in the spring. If the trees are not fully protected when an infection period occurs, an immediate application of fungicide will be more valuable than one applied later in the season when scab lesions become visible on leaves or fruitlets.

TABLE 3

Extent of Use of Different Spray Materials for Apple Scab Control, 1960

Material	Percentage of all applications in survey orchards			
	On Cox's Orange Pippin		On Bramley's Seedling	
	Pre-blossom	Post-blossom	Pre-blossom	Post-blossom
Organo-mercury	7·4	1·3	24·4	33·0
Organo-mercury + sulphur *	4·4	0·2	7·5	7·6
Organo-mercury + captan ...	2·0	1·3	2·5	0·3
Captan	40·8	59·4	4·4	12·1
Captan + sulphur *	7·9	9·9	0·3	2·3
Lime sulphur	16·7	0·0	42·1	16·8
Lime sulphur+sulphur* ...	2·5	0·9	7·2	3·7
Sulphur *	17·5	24·1	11·0	23·9
Other materials	0·8	2·9	0·6	0·3
Total	100·0	100·0	100·0	100·0
Mean No. of applications (All materials)	3·7	3·9	3·2	3·8

* As wettable or colloidal sulphur

SUMMARY

A total of 743 spray programmes were examined in the course of a survey of apple scab spraying practice for Cox's Orange Pippin and Bramley's Seedling in English commercial orchards during the years 1958-60. On both varieties the number of spray applications during the season ranged from 5 to 9, and

these were generally given at fixed intervals with little regard to bud stages or to infection weather. Captan was the fungicide most extensively used on Cox's for scab control, with sulphur sprays in the second place. Organo-mercury preparations were the sprays most extensively used on Bramley's Seedling.

In all three years of the survey the incidence of scab in the survey orchards was generally low. Those orchards in which 10 per cent or more of the fruit showed some scab at picking time were generally found to have been unprotected by spray applications during the first infection periods occurring at or after bud burst.

The Conference of Plant Pathologists thanks all those growers, Horticultural Advisory Officers and research workers who participated in this survey during the three years.

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ARYLMERCURY SPRAY RESIDUES IN APPLES

by N. A. SMART

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ARYLMERCURY compounds, such as phenylmercury acetate and 8-phenylmercurioxyquinoline, have been used for some years in this country in fungicidal sprays for the control of apple scab, *Venturia inaequalis* (Cooke) Wint. In 1958 the Scientific Subcommittee on Poisonous Substances used in Agriculture and Food Storage reviewed this use of organo-mercury compounds. At the time a certain amount of residue data was available (Miller, 1956; Martin and Pickard, 1960), but without further information the Subcommittee was reluctant to accept that an interval of less than eight weeks between the last application of a spray and harvest of the crop was sufficient to ensure that residues of mercury reaching the consumer were not harmful. The work described here provided further independent data on the mercury spray residues likely to be encountered at harvest.

In August and September, 1959—after a warm dry summer in the south of England—samples of fruit were taken from eight commercial Bramley's Seedling orchards that had been sprayed with arylmercury formulations. The rates of application had been those recommended by the manufacturers, i.e., of ·02 to ·08 lb of organically combined mercury per acre, at each application. A control sample of Bramley's Seedling apples, known not to have been

sprayed with an arylmercury compound, was obtained from a local orchard. After storage at −10°C for two or three months until required for analysis, all the apples in each sample were diced (with skin and core), thoroughly mixed, and aliquots of 50 g were taken.

The method of analysis used was based on the modification by Abbott and Johnson (1957) of that of Klein (1952). Aliquots containing 4·6 μg mercury from a solution of phenylmercury acetate were added to 50 g of a sample of unsprayed apples and in four determinations 4·3, 3·4, 4·2 and 4·6μg of mercury were found, showing a mean 90 per cent recovery by the method used.

The residue data obtained (without correction for recovery) for the apples from the sprayed orchards, with relevant particulars of the spray programmes, are given in the Table. Unsprayed apples gave a negligible residue (less than 0·005 p.p.m. mercury).

Mercury Residues in Fruit from Bramley's Seedling Orchards, in relation to Number and Dates of Application of Arylmercury Fungicides, 1959

Orchard	Arylmercury applications		Weeks from last spraying to harvest	Arylmercury compounds used	Residues found (p.p.m. mercury)
	No.	Dates			
1. Bucks	7*	April 24 May, 8, 16, 26 June 10, 24 July 15	5	Phenylmercury acetate and 8-phenylmercuri-oxyquinoline	nil, 0·01, 0·02
2. Surrey	8	April 2, 20 May 9, 25 June 7, 18 July 6, 30	5	Phenylmercury acetate	0·075, 0·065
3. Surrey	6	May 15, 23 June 9, 23 July 7, 27	6	Phenylmercury chloride	0·05, 0·065
4. Kent	2	May 15, 22	16	8-phenylmercurioxy-quinoline	0·01, 0·02
5. Kent	7	May 14, 25 June 6, 17, 30 July 14 August 1	5	Phenylmercury chloride	0·02, 0·02, 0·035
6. Cambs	4*	April 1, 29 May 12 June 2	14	Phenylmercury acetate	nil, 0·015
7. Norfolk	4*	May 2, 22 June 12, 24	10	Bis-phenylmercury methylenedinaphthalene sulphonate	nil, nil
8. Herts	1*	April 21	20	8-phenylmercurioxy-quinoline	nil, nil

* Applications at high volume; others low volume.

The official recommendations for the safe use of arylmercury fungicidal sprays*, published in 1960, allow the application of these sprays until the end

* Obtainable from the Ministry of Agriculture, Fisheries and Food, 5-8 St. Andrew's Place, London, N.W.1.

of July provided this is not less than six weeks before harvest. On present information a residue of mercury not exceeding 0·1 p.p.m. of the fresh weight of the harvested apple crop should not present a hazard to consumers. In the above work the residue was, for the most part, well below 0·1 p.p.m. mercury and only in the fruit from two orchards did it approach that figure.

I thank Mr. T. F. Preece of this laboratory for obtaining samples and providing spray programme data.

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INACTIVATION OF TOMATO MOSAIC VIRUS IN TOMATO SEEDS

by R. HOWLES

Glasshouse Crops Research Institute, Littlehampton

MOST tomato crops become infected with tomato mosaic virus during growth and seeds saved from infected fruits carry the virus in their testas. A small proportion of seedlings grown from these become infected under commercial conditions and are then sources for spread within the new crop. Several attempts have been made to free seeds from virus by chemical treatments, but none is considered to be entirely satisfactory. Previous work on virus inactivation in tomato seeds by heat treatment or soaking in water (Howles, 1951, 1952, 1957) has been continued.

HEAT TREATMENT

Seeds from infected tomatoes of the variety Potentate were cleaned by fermentation, dried, separated and well mixed. Soon after harvest or after a year's storage 2g lots were heated in an incubator at 72°C for 22 days. Virus content was then estimated by grinding 180 seeds with "Celite" in 10 ml distilled water and inoculating half-leaves of 10 young *Nicotiana glutinosa* plants with the suspension, the opposite halves being inoculated with a similar suspension of untreated "control" seeds from the same batch. Heat inactivated most of the virus in the fresh seed but did not eliminate it (see Table). There was less effect on the virus content of the year-old seeds.

To find if the treatment affected germination or seedling growth, 100 treated and 100 untreated seeds were sown; germination, seedling appearance, cotyledon length and seedling dry weight were recorded. Differences were negligible if allowance was made for a 2-day delay in germination after heat treatment.

SOAKING IN WATER

Previous experiments had suggested that virus was inactivated or leached from the testa during germination in water in Petri dishes at room temperature. To test this further, seeds were soaked until the radicles began to appear (about 8 days) and then dried, and samples were tested as described above. Soaking had the same effect on virus content of fresh seed as heat treatment had. Soaking heated seeds or previously soaked fresh seeds for another 5 days further decreased virus concentration. Soaking previously soaked year-old seeds had much less effect on virus content.

Germination in water would be difficult for a grower to control, but the heat treatment may have a practical application.

Effect of Heat (72°C for 22 days) and Soaking in Water on Concentration of Tomato Mosaic Virus in Tomato Seeds

Treatment	Seed age	No. of tests	Mean lesion count (*N. glutinosa*)	
			Untreated	Treated
Heated	Fresh	9	220	10
Heated	1 year	6	88	13
Heated + soaked ...	Fresh	6	235	3
Heated + soaked ...	1 year	3	120	9
Soaked	Fresh	9	232	15
Soaked, dried, re-soaked ...	Fresh	3	237	8
Soaked, dried, re-soaked ...	1 year	6	64	15

SUMMARY

Heating tomato seeds infected with tomato mosaic virus for 22 days at 72°C decreased virus content to a low value without adversely affecting the subsequent seedlings, apart from delaying germination for 2 days. Germinating seeds in water also decreased virus concentration.

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TIME-TEMPERATURE REQUIREMENTS FOR KILLING *VERTICILLIUM ALBO-ATRUM* IN HOP BINE

by P. W. TALBOYS

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THE introduction of the stationary hop-picking machine has brought with it the problem of disposing of the large quantities of stem and leaf material which accumulate at the picking-shed. A common practice is to carry out a crude form of composting in which the leaf debris, and the chopped bine delivered from an auxiliary cutting-machine, are stacked in the open and allowed to rot for 6-12 months before being distributed elsewhere as an organic manure.

On farms where Verticillium wilt is present this operation provides a potential hazard for susceptible crops, for the possibility exists that at least part of any diseased material so treated may remain infective because heating of the stack has been uneven or otherwise inadequate to destroy the pathogen.

There appears to be virtually no information available on the efficacy of composting as a means of destroying *Verticillium albo-atrum* in plant debris, but the following experiments, to find the minimum times required to kill the pathogen in infected hop bine fragments at various temperatures, form a contribution to a joint study of the problem by Wye College Hop Research Department, East Malling Research Station and the National Agricultural Advisory Service.

METHODS

Heat treatments were carried out in tightly plugged thin-walled test tubes, each containing three 1-1½ in. lengths of infected hop bine. These samples were heated in a thermostatic water-bath when treatment times were less than 8 hr and in an incubator when longer treatments were required.

At intervals, ranging from 15 min in high-temperature treatments to 48 hr at the lowest temperature, three tubes were removed and their contents transferred to plates of prune-lactose-yeast agar (Talboys, 1960). These were incubated at 23°C for about 10 days, after which the presence or absence of living *V. albo-atrum* in each fragment was recorded. For each temperature the shortest treatment giving a completely negative record on the plates was taken as the killing-time.

The first experiments were made with naturally-infected bines collected from the field, but after the milder heat treatments the presence of numerous rapidly-growing saprophytic contaminants on the plates made it difficult to determine whether or not *Verticillium* was present. In the main experiments, therefore, the samples consisted of pure cultures of the pathogen growing on sterile bine fragments. 500 ml conical flasks containing 40 g dry chopped bine and 100 ml water were sterilized, inoculated with a spore suspension of *V. albo-atrum*, and incubated for three weeks at 23°C. The substrate became thoroughly permeated by the fungus, and both hyaline and darkly pigmented mycelium were present, together with conidia. Samples were then transferred to sterile plugged tubes for the experimental treatments.

RESULTS

The killing-times for an isolate from a progressive wilt outbreak were:

60°C	55°C	50°C	45°C	40°C
15 minutes	1 hour	3 hours	12 hours	7 days

After 10 days at 35°C the pathogen was still viable in about 80 per cent of the fragments, and some fragments still yielded *Verticillium* after 28 days at this temperature.

Similar results were obtained with an isolate from a fluctuating wilt outbreak, though this was tested only over the 40°–50°C range.

DISCUSSION

In the absence of evidence to the contrary it is assumed that the heating of the compost, rather than microbiological antagonism, will be the primary factor responsible for the destruction of *Verticillium*.

Obviously, the higher the temperature that can be achieved, and the longer it can be maintained, the more reliably will the pathogen be eliminated. The data presented above merely indicate the *minimal* requirements that must be satisfied throughout the *whole* of the material.

In applying the results, allowance must be made for the fact that the experiments were carried out under uniform conditions and with relatively uniform samples of infected bine. It is to be expected that killing-times will vary slightly with different materials and under different conditions, and a reasonable safety-factor may therefore be desirable.

From a practical point of view the critical temperature range appears to fall between 40 and 45°C (104-113°F). Allowing a two-fold safety factor, increasing the temperature from 40 to 45°C would reduce the necessary time from 14 days to 24 hours. A further increase to 50°C (122°F) would reduce the time to six hours. However, the work of Phillips (1959) on composting tomato haulms shows that it will not be easy to achieve or to maintain such temperatures at the periphery of simple heaps or pits, and it seems likely that if efficient turning of the mass is impracticable it may be necessary to develop some means of insulating it to reduce peripheral heat losses.

SUMMARY

Laboratory experiments have shown that to kill *V. albo-atrum* in hop bine fragments it is necessary to maintain a temperature of 40°C (104°F) for at least 7 days, 45°C (113°F) for 12 hours, 50°C (122°F) for three hours, or 60°C (140°F) for 15 minutes. The data provide the minimum requirements to be satisfied throughout the whole of a mass of compost to ensure destruction of the pathogen.

I am indebted to Miss M. K. Davies for technical assistance.

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OATS AS A TRAP-CROP FOR CEREAL ROOT EELWORM

by L. E. W. STONE

National Agricultural Advisory Service, Cardiff

CARROLL and McMahon (1937, 1939) found that the efficiency of potatoes as a trap-crop for *Heterodera rostochiensis* Woll. was limited because of the difficulty of removing all the roots from the soil when the host plant was destroyed. Using oats to trap the larvae of *H. avenae* Woll. seemed likely to be more successful.

Cereal root eelworm was associated with a failure of oats in a field near Salisbury, Wiltshire, in 1955. An area 50 by 30 yd in this field, which had an estimated population of 30 eggs per g, was sown with Sun II oats on March 27, 1956. In early June, when white cysts were found on the roots, three strips 5 yd wide were ploughed in. The remaining oats made very poor growth. Oats were resown over the area on April 3, 1957. As this second crop was also very poor, the same strips were ploughed in again in mid-June, 1957. Oats were sown for the third time in 1958 and they grew markedly greener and taller on the previously ploughed strips than on the others. The following data were obtained:

Treatment	Mean No. of eggs per g of soil			Yield lb/acre
	September 1956 After 1st ploughing	September 1957 After 2nd ploughing	September 1958 After oats	
Oats	28·4	16·8	16·3	475
Ploughed	2·2	1·1	2·4	1,145

It will be seen that the strips growing oats continuously failed to maintain the original population of *H. avenae* and that although the mean yield was more than doubled by the treatment, it was still only about half one might expect for spring oats. The site was, however, very exposed and weedy and there was considerable damage by birds and frit fly.

Although no fallow plots were available for comparison, it does appear that oats are an efficient trapcrop for *H. avenae*, and that ploughing-in severely attacked spring oats at the right time will markedly reduce the population in the soil. The ground can still be used for a root crop in the same year, and cereals grown in the following year are not likely to suffer eelworm damage.

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ASSESSING THE ACTIVITY OF THE FIELD SLUG IN CEREALS

by CECILY M. DUTHOIT

National Agricultural Advisory Service, Reading, Berks.

NEWLY sown winter wheat seeds provide an immediate source of food for the field slub, *Agriolimax reticulatus* (Müll.). Laboratory and field tests at Reading show that the slug eats the germ first and then the endosperm. Brown (1955) obtained similar results in East Anglia.

The 1960-61 winter season was wet and mild and in a number of crops seed loss was heavy before germination. Slug activity continued, even when frosts were recorded, an observation that confirms the finding by Mellanby (1961) that *A. reticulatus* continues to feed at 0·8°C. Field sampling for cereal seeds is difficult, particularly under wet and muddy conditions and a new type of row trap has been devised to speed up and simplify work on the quantitative assessment of slug activity and damage.

The trap unit consists of a piece of terylene netting, 1 mm mesh, 6×4 in. in size, which is pressed firmly an inch or two below soil level between drill rows. Ten winter wheat seeds are placed in a groove pressed lengthwise in the centre of the terylene mat. Mat and seeds are covered by a double thickness of sacking and the entire trap is tethered firmly to the ground by two stout wire clamps. Traps are put out 12 yards apart at a density of 25 per acre and can be left for any desired period, the terylene being rot-proof.

When collecting the samples the unit is opened by removing the wire clamps and the netting with seeds is placed in a numbered polythene bag after removal. Assessment of seed damage and identification of the slugs are done in the laboratory. New mats with fresh seeds can be set at each unit site if successive activity estimates are required. A difficulty which has arisen in some fields is that the long-tailed field mouse, *Apodemus sylvaticus sylvaticus* (L), has raided traps for the grain and on occasions gnawed and removed the mats.

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THE ECONOMIC PLANT DISEASES OF SCOTLAND

A survey and check list covering the years 1924-57, by C. E. Foister, Director, Scientific Services, Department of Agriculture and Fisheries for Scotland, was published under the above title in August, 1961, as the Department's Technical Bulletin No. 1, by Her Majesty's Stationery Office, price 10*s.* (by post 10*s.* 9*d.*). The Bulletin, which contains 209+iv pages, 8vo, is designed as a work of reference. Part I, pp 4-86, deals with the distribution, economic importance and yearly occurrence of plant diseases and disorders, arranged in substantial paragraphs under crops. Part II, pp 87-159 is a check list of diseases arranged under the Latin names of the plants affected, with notes on symptoms where the disease has no common name. Part III, pp 161-209, contains separate indices of parasites, viruses, non-parasitic disease agents and common names of host plants; a list of some 400 literature references with titles in full; and details of the Scottish certification schemes.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

Gout Fly Damage to Spring Wheat. In August, 1960, samples of Atle spring wheat from two fields from the same farm at Fosbury, near Marlborough, were badly infested with gout fly, *Chlorops pumilionis* (Bjerk). There were two forms of damage: obviously "gouted" plants, where the ears had failed to emerge, and plants with malformed and only partly emerged ears which, together with the stems, plainly showed larval feeding grooves. There were no symptoms of attack by frit fly or other graminaceous Diptera. The two crops were different in appearance and in previous crop history. The 22-acre field came out of a 7-year ley in 1959 and was cropped with Proctor barley, while the 30-acre field came directly out of a 7-year ley. Cultivations for 1960 were delayed through wetness and the crops were sown late March-beginning April.

Upon examination, two types of plant were noted in the 22-acre field: those that had developed from primary shoots, some of which had produced ears, and those, the majority, from very late tillers of which only a few had produced ears which were still in anthesis. The 30-acre field looked normal, but the crop was very backward. Again, some ears were about to ripen, while others were in anthesis; there were only slight differences in plant height. On single transects of both fields, at 5 yard intervals, estimations of infestations were made on 1 ft rows of crop. From 25 points in the 22-acre field, there were 94 "gouted" plants (range 0-8 per ft) and of the sparse ears 8 were malformed. The infestation was surprisingly even across the field. In the other field, from 30 points 36 gouted plants were counted (range 0-3 per ft), but only 15 ears were grooved by larval feeding. The attack was smaller further into the field, but here some other factor had caused some plants to sever completely between the first and second nodes; there was no evidence of wheat stem sawfly. For these two complementary reasons the impression of uniform backwardness in ripening throughout the crop was maintained.

The source of the infestation was thought to be the wide, permanent grass roadways and hedgerows which were contiguous with some parts of both fields; the most extensive area coincided with the whole of one side of the worst infested field. It is also likely that some factors associated with crop cultivations and weather were involved. The dry, early summer weather probably held back the crops initially making them susceptible to attack, and the change in weather in mid-summer may only then have allowed late tiller production and normal growth. Both crops were complete failures.

E. B. DENNIS

Eelworm in Cineraria. In December, 1960, *Aphelenchoides ritzemabosi* (Schwartz) was found in a few very puckered and wrinkled leaves (Plate III, 2) taken from a pot plant of cineraria, *Senecio cruentis* DC., growing in a greenhouse at Poole, Dorset, in close proximity to chrysanthemums, all of which were severely eelworm-infested. Of the stock of cinerarias only one plant was affected, and on this plant not all the leaves showed symptoms. The eelworm may have been transferred by handling. This is a new host record for *Alphelenchoides ritzemabosi*.

E. B. DENNIS

A Bud-rot and Twig-canker Disease of cultivated Hazel. In May, 1955, specimens of dead cobnut buds and twigs were brought to East Malling Research Station by Mr. C. D. Reekie (N.A.A.S., Kent), and on investigation at the site—a small commercial plantation at Mereworth, Kent—a group of old bushes was found to be so severely affected that their crop was ruined. Moreover, the paucity of leaves when the bushes should have been fully foliated (Plate II) gave the affected patch a scorched appearance in striking contrast to its green surroundings. During the next few years the disease seriously encroached on most of the two-acre holding, although single interplanted bushes of filbert pollinators were little affected. Before mention of this case in *Rep. E. Malling Res. Sta. for 1959*, p. 24, and *ibid for 1960*, p. 26, the disease appears to have been unrecorded, but there is reason to think that it has been present in cobnut plantations over a long period. It has now been found on wild hazel in several hedgerows, and, sometimes to an epidemic extent, on other holdings in Kent. On incubation in spring most of the rotted buds and twig cankers soon become warted with small white pustules of *Gloeosporium* sp.; any that do not have probably been killed, as occasionally happens, by other common rot fungi (species of *Botrytis, Fusarium, Cladosporium* or *Penicillium*). The growth of the *Gloeosporium* frequently extends from a rotted bud to the adjacent twig, forming a nodal canker which kills the distal part of the twig. Spores from freshly-rotted buds and twigs are unicellular, hyaline, granular often with a clear centre, tapered at one end, and range from $10{\cdot}4-20{\cdot}5\times4{\cdot}6-7{\cdot}1\mu$ (mean $15{\cdot}6\times6{\cdot}1\mu$).

M. H. MOORE

Cabbage Root-fly attacking the growing points of Mustard. There are several references to larvae of *Erioischia brassicae* Bouché attacking the aerial parts of brassica plants, and Thomas *(Plant Pathology*, **5**, 114, 1956) found larvae mining in the growing points of stocks. In recent years several varieties of *Brassica juncea* and other *Cruciferae* have been grown in randomised block experiments at Anstey Hall, Cambridge, to discover any varietal differences in susceptibility to attack and damage by various pests. Cabbage root-fly larvae were often found causing normal root damage and also feeding inside the basal inch of stem on Trowse mustard *(B. juncea* Coss). In May, 1959, cabbage root-fly larvae were found mining and destroying the growing points and surrounding young leaves of one of the varieties of *B. juncea*, a leaf-mustard, originally from Japan. There were two distinct types of plant in this variety, one which had entire lettuce-like leaves and a compact habit, and the other with finely divided leaf-laminae and an erect habit. The root-fly damage in the crowns occurred mainly on the lettuce-like plants, which formed roughly half the plant population on the four plots of this variety. One hundred plants were examined on each plot, and it was found that 39·7 per cent of the plants showed symptoms of crown damage. This represented a 79 per cent attack on the lettuce-like plants. The damage delayed flowering by nearly three weeks, and inflorescences produced by attacked plants were poorly developed. Crown damage did not occur on the five other species grown in the trial; Arlo turnip-rape, *B. campestris var. oleifera sub-var. annua* Metz; White mustard, *Sinapis alba* L; Black mustard, *B. nigra* Koch; Trowse mustard, *B. juncea* Coss; and a variety of *B. juncea* similar to Trowse from Stalingrad. The crown attack may be associated with the growth habit of the plants. The attacked plants carried their growing points not more than one inch above soil level. During May the growing points of the unattacked plants were carried on stems several inches above the ground.

A. L. WINFIELD

Melanospora damnosa associated with _Fusarium culmorum_ on Cereals. In June, 1961, oat tillers or whole plants with red leaves scattered through a crop in South Mundham, Sussex, had the lower parts severely infected by *Fusarium culmorum*, the mycelium often showing the characteristic bright pink colour. Perithecia found embedded in or closely associated with the *Fusarium* on nodes, straws and leaf sheaths were identified as *Melanospora damnosa* (Sacc.) Lindau. During the next two months the two fungi were found together on oats with reddish leaves, on barley and on prematurely ripening wheat (on Broadbalk and other fields) at Rothamsted Experimental Station, Herts., on wheat near Hitchin, and on barley near Winchester, Hants. Perithecia of *M. damnosa* were then found by Mr. D. Slope on slides prepared in 1959 from a culture of *Fusarium* isolated from wheat at Rothamsted. The perithecia were globose, honey-coloured, and measured 140-350μ with beaks ranging from about 40-140μ with bristles at the top; asci, which were evanescent and seen only in immature perithecia, were clavate and contained eight ascopores; mature ascopores were lemon-shaped, olivaceous, vacuolate and measured 21 $\times$ 12μ (range 18-23 $\times$ 9-12μ) (Plate III, 1). These measurements correspond with those given by Doguet *(Le genre 'Melanospora': biologie, morphologie, développement, systématique*, Bordeaux, 1955, p. 118).

The fungus, first found by Professor Cettolini on cereals in Sardinia in 1895, was described as *Sphaeroderma damnosum* by Saccardo (in Saccardo, P. A. & Berlese, A.N., *Riv. Pat. veg., Padova*, 1895, **4**, 56-65) who, because of the close association of the fungus with *Fusarium* conidia, included a description of these as the imperfect state in his diagnosis of the ascomycete. Observations on the very severe disease attributed to this fungus in Sardinia in 1895 and 1896 are given in this paper and a subsequent one (*ibid.* 1896, **5**, 88-97). Goidanach found similar symptoms associated with the same fungi on wheat, barley and oats in Sardinia in 1946 *(Italia agric., 1947*, 1, 7 pp.); investigations by Goidanach and Mezetti *(Ann. Sper. agr.*, 1947, **1**, 123-9 and *ibid.* 1948, **2**, 489-514) showed that the two fungi are distinct but that growth and reproduction of the *Melanospora* is stimulated by the *Fusarium*. *M. damnosa* has also been noted on cereals in Tunisia (Boeuf, F., *Bull. Dir. Agric. Tunis.* 1903, 27), and Gentner *(Prakt. Bl. PflBau*, 1925, **3**, 6-9) recorded it on oat seed from Germany. It has not hitherto been reported on cereals in Britain, where the only previous record is on elm (Mason, E. W., *Mycol. Pap.* 3, 1933, p.44); but Dr. C. Booth of the Commonwealth Mycological Institute, who confirmed the identification of our fungus, reports that the *Melanospora* found on elm at Kew is distinct from *M. damnosa*, and is probably a new species.

MARY D. GLYNNE and F. JOAN MOORE

CORRECTIONS

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On p. 31 it was inadvertently stated that the swede variety 'New Zealand Y' is a selection of 'Wilhelmsburger.' The variety, now known as 'New Zealand Wye,' is however a selection from lines imported into New Zealand but of unknown origin. It is said to be almost immune to club root in New Zealand. L. A. WILLEY

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Fungi on Highbush Blueberries. pp. 123-4. This contribution was not by H. J. Wilcox and Margaret A. Falconer as printed, but by ELIZABETH G. GRAY and H. F. M. EVERETT.